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Project Management Complexity: An Organisational Learning perspective

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ABSTRACT

Project complexity is defined as an inherent characteristic of a project that results from the interrelations and the dynamics among its many parts, but also as something which is experienced by people working in projects, including both negative (in terms of difficulty to understand, to foresee and to keep under control) and positive aspects (emergence). Both scholars and practitioners in project management extensively acknowledge the importance of evaluating complexity and emergent properties of projects. The appropriate approaches and managerial actions to understand and address the increasing complexity of projects are a key determinant of the success of the organisations, especially the project-based ones. Therefore, there is the need to identify both the elements that define a project being complex and the relationship between the level of complexity and the resulting project outcomes. The growing trend in the publications and the living interest on these topics (with the first studies published in the early nineties) resulted in a fragmented literature. How dealing with project complexity in project management literature and practice still remains a major point of discussion and needs additional conceptual and empirical investigations.

This thesis aims to investigate how organisations face the complexity in projects and in project management from an organisational learning perspective. A systematic literature review on project complexity allowed to identify and summarise the main research streams in a holistic view of the literature on project complexity. Previous studies have prominently focused on understanding and characterising project complexity, measurement models and methods, the relationship between project complexity and success, practices and strategies to cope with project complexity. Among the main gaps identified, little research focused on the elements of complexity in a multi-project environment, e.g. in project-based organisations, and considered the hierarchical aspects and the emerging dynamics, e.g. learning. Drawing on project-oriented and organisation studies, a subsequent review of the literature on learning in project environments revealed the key issues of dealing with project constraints and the need to build knowledge communities. This is mainly due to the temporary organising of project teams and distributed knowledge and project management practices among them, with difficulties to share and transfer the lessons learned to the overall organisation and to achieve organisational learning, i.e. the learning process at organisational level. Focusing on the scope of project organising, this thesis integrates insights and concepts from project complexity and organisational learning literature to study emerging patterns, challenges and elements of complexity in single and multi-projects environments. These are studied in the light of the learning processes within projects, i.e. in project management teams, and in the overall project-based organisations where projects are embedded.

Therefore, the research questions were formulated as follows: 1) How do organisations understand and face project management complexity within their projects from an organisational learning

perspective? 2) How can organisations face project management complexity across their projects from an organisational learning perspective?

We conducted an exploratory, embedded case study research in a leading company in the shipbuilding industry. The contextual features of a project-based organisation allowed to investigate the dimensions of project complexity identified in literature (i.e. diversity, interdependence, dynamicity, uncertainty) and the patterns and mechanisms of organisational learning (processes, levels and issues such as project constraints and distributed project management practices in knowledge communities) within and across the projects embedded in a common organisational context.

Focusing on the processes of experience accumulation, knowledge acquisition and knowledge accumulation, the resulting interpretative framework for complexity and organisational learning in project environments determines further insights on studying organisational learning as an emergent process. In general, complex projects show a considerable level of all the sub-processes of organisational learning, taking place in the project team. For instance, a higher level of both interdependency and dynamicity results in a higher knowledge codification. Beyond the experience of the project team members, dealing with several interfaces (e.g. customers, suppliers, subcontractors, other functional units) and pace of the projects (e.g. introduction of several changes during the implementation phases, strict regulations) allows for a better learning at organisational level. A higher diversity mainly results in the need to acquire knowledge from the external sources, and in particular on the previous projects, the previous experiences of the team members and also the competences of the main stakeholders, when properly shared. The dynamicity requires both knowledge acquisition and codification, mainly addressing issues that are specific of the ongoing project at the operational level. Finally, higher uncertainty requires relying on the ongoing experience-based learning. Overall, the complexity of projects tends to bring to informal mechanisms of knowledge codification and knowledge communities formation, to be properly shared and transferred in the upcoming projects.

Dealing with multiple projects carried out in parallel has several implications also on the organisational learning processes that can take from project to project and from the single projects to the overall organisation. The project management teams have to face several interfaces at the operational level, mainly due to the conflicts between the temporary organising and the presence of multiple stakeholders. Dealing with the dimensions of diversity, interdependence, dynamicity and uncertainty in the project portfolio requires to promote informal practices to share reflections on the more structured, across-projects level processes, in order to address specific issues that could become synergic among multiple projects and respond to both customer and internal integration needs. This consideration implies the adoption of tools and not restricted, bureaucratic procedures to access the solutions already implemented and to stimulate organisational routines. From the one side, higher levels of diversity among projects require a systematic knowledge codification in knowledge management systems for consolidated project management practices. From the other, the dynamicity due to the management of projects in parallel requires the integration between the bottom-up experience, especially in terms of changes and challenges that can be potentially faced by more than one project team, and top-down initiatives from the overall organisation, such as the creation of knowledge communities.

Although the results from a single case study cannot be easily generalised, there are some important implications. From a literature point of view, the contributions and added value of this thesis are threefold. Firstly, the systematic literature review on project complexity allowed to identify the main research topics, the main gaps and outlined possible directions for future research. Secondly, taking into account the organisational learning process as a perspective for understanding complexity allowed to further enrich the insights obtained from the conceptualising of complexity

in a project environment. Results have been condensed in an interpretative framework along two dimensions, represented by (1) the dimensions of complexity mainly cited in the literature on project complexity, (2) the key sub-processes and challenges of organisational learning in ongoing projects. Managerial implications are mainly in understanding the processes of experience accumulation, knowledge acquisition from other projects and sources and knowledge codification as resulting from the practice-based level and top-down initiatives. The proposed analyses may help project managers and other project stakeholders to better understand the complexity of the projects they are working on, in addition to reflect on motivations, behaviours and organisational initiatives to foster learning at the organisational level. These should be addressed to stimulate informal mechanisms of knowledge articulation and codification, without imposing standardisation of procedures.

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INTRODUCTION

I.1 RESEARCH BACKGROUND

This dissertation addresses one of the major topics under investigation in the recent project management literature, i.e. the complexity in projects and in project management, and how organisations are dealing with it. Project complexity can be defined as an inherent characteristic of a project that results from the interrelations and the dynamics among its many parts (Baccarini, 1996; Lu et al., 2015; Xia and Chan, 2012). From the perspective of the people working in projects, it is something which is perceived or experienced, including both negative (difficult to understand, to foresee and to keep under control) and positive aspects (emergence) (Bosch-Rekveldt et al., 2011; Dawidson et al., 2004; Vidal et al., 2011), resulting from the dynamic changes in the environment, increased product complexity and project constraints (Williams, 1999).

A project can be defined as being complex as it is characterised by its complexity footprint (Bosch-Rekveldt et al., 2011) in terms of the large number of components that highly interact with each other (Whitty and Maylor, 2009). Complexity – and its growth at a faster rate than the capability to cope with (Maylor and Turner, 2017) – has been recognised as a major topic of discussion in project management research and practice (Lessard et al., 2014; Luo et al., 2017). The concept of complexity has gained interest for several reasons.

Firstly, complexity has been defined as one of the causes of projects failure if underestimated or not properly managed (Brady and Davies, 2014; Bosch-Rekveldt et al., 2011; Williams, 1999). Equally, the application and mastering of complexity has been increasingly recognised as a key to improving performance and understanding of project management (Aritua et al., 2009) and consequently determining the appropriate managerial actions to complete a project successfully (Baccarini, 1996). According to PMI, "how organisations anticipate, comprehend and navigate complexity determines their successes and failures" (PMI, 2013b). It has to be considered in the variables affecting the relationship between project performance and contextual conditions, i.e. organisational setting and managerial choices (Baccarini, 1996; Lessard et al., 2014). Moreover, complexity is considered a source (either direct or indirect) of risks in projects (Vidal and Marle, 2008).

Secondly, the complexity of most projects is rapidly increasing (Williams, 1999). Projects are becoming more complex, with components more independent, and adapting to more volatile environments (Augustine et al., 2005). This implies a difficulty to coordinate (Davies and Mackenzie, 2014) and control all aspects of the project (Gransberg et al., 2013). Dealing with the interdependency, uncertainty and change of contemporary projects (Davies and Mackenzie, 2014) and the dynamic environments in which they operate poses new challenges (Cooke-Davies et al., 2007) and requires a different approach (Williams, 2002; Bosch-Rekveldt et al., 2011). Many studies have recognised that traditional project management methods towards the "Tayloristic one best-way approach" as a reference model to apply to any type of project or industry, and conventional linear systems are not more sufficient to properly address the increasing complexity of projects (Costantino et al., 2015; Williams, 1999; Winter et al., 2006). The understanding of project complexity should be then progressively developed (Chapman, 2016) in order to better configure the front-end phase (Bosch-Rekveldt et al., 2011) and then achieving – and improving – duration (schedule), quality and cost (budget) goals for project success (Dawidson et al., 2004). Moreover, an objective measure of complexity could provide continuous feedback to help control the process of project development (Baccarini, 1996; Xia and Chan, 2012).

This is true especially in multi-projects environments, such as the project-based organisations, defined as a type of organising where projects are the primary units for coordinating and integrating production, organisation, innovation and competition (Hobday, 2000; Lundin and Söderholm, 1995; Whitley, 2006). The mainstream activities are entirely (or mostly) based on projects, usually for the design of bespoke solutions (Koskinen, 2012) and the production of one-off, unique products to fulfil the requirements of customers (DeFillippi and Arthur, 1998; Gann and Salter, 2000; Hobday, 2000). These organisations face specific challenges when capturing, sharing and embedding new knowledge and learning from projects at the overall organisation level (Brady and Davies, 2000; Bresnen et al., 2004; Keegan and Turner, 2001; Lundin & Söderholm, 1995). This is mainly due to the decentralised organising of the teams, the interfaces between the temporary and permanent organisation (Stjerne and Svejenova, 2016) and the ways of working constrained by tight schedules and optimisation towards the achievement of the single project goals, resulting in distributed knowledge and working practices (Bresnen et al., 2004; Lindkvist 2004; Orlikowski 2002). A consideration of the contextual conditions (e.g. level of complexity of the projects) for organisational learning and the processes of emergence is therefore required (Maguire et al., 2006; Mitleton-Kelly and Ramalingam, 2011), overcoming the limits of studying learning outcomes in a static environment (Sorenson, 2003). Teams are indeed defined as the fundamental unit of learning and organisational effectiveness (Leonard-Barton, 1995; Nonaka and Takeuchi, 1995; Senge, 1990). A complexity perspective can offer a point of view to explore the 'black box' of organisational learning concept in terms of process, scope, conditions and issues such as adaption, alignment and equilibrium (Mitleton-Kelly and Ramalingam, 2011).

I.2 RESEARCH AIMS AND RESEARCH QUESTIONS

Despite the increasing interest towards project complexity, there is a lack of common understanding of project complexity, mainly due to the different theoretical lenses and influencing factors considered in the analysis. Little research focused on the elements of complexity in a multi-project environment, e.g. project-based organisations, and considered the hierarchical aspects and the emerging dynamics, e.g. learning. Moreover, the learning process at organisational level tackles the key issues of project constraints and the need to build knowledge communities. This is mainly due to the temporary organising of project teams and distributed knowledge and project management practices among them, with difficulties to share and transfer the lessons learned to the overall organisation.

This thesis aims to investigate how organisations are facing the complexity of their projects based on the reflections and perspectives of the members with key roles in the project management process of a project-based organisation. Focusing on the scope of project organising, the objective is to integrate insights and concepts from project complexity and organisational learning literature to study emerging patterns and elements of complexity in single and multi-projects environments. These are studied in the light of the learning processes within projects, i.e. in project management teams, and in the overall project-based organisations where projects are embedded.

Therefore, the research questions were formulated as follows:

1) How do organisations understand and face project management complexity within their projects from an organisational learning perspective?

2) How can organisations face project management complexity across their projects from an organisational learning perspective?

The final goal is to gain a deeper insight into project complexity as a feature of projects influencing learning processes of project teams and project-based organisations. The thesis is particularly concerned with the practical aspects of learning where project organising supports the main business of companies, viewed from a project management perspective.

I.3 RELEVANCE OF THE RESEARCH

Nowadays, project management literature and practice show a great interest in understanding projects in terms of complexity theory, self-organisation and emergence (Gordon and Curlee, 2010). Practitioners widely acknowledge the importance of identifying both the conditions that give rise to project complexity (Antoniadis et al., 2011) and the effects on project outcomes – i.e. project duration, cost, and quality (Xia and Chan, 2012) – within the project management process (Baccarini, 1996). Also from a literature point of view, the extensive number of scientific publications over the last two decades demonstrates the relevance of the concept of complexity in current project management research (Bosch-Rekveldt et al., 2011). On the one hand, complexity appears among the main topics of the broadening scope of project management research according to Söderlund (2004). This is confirmed by Svejvig and Andersen (2015), who recognise complexity – and uncertainty – as one of the overarching categories covering the "rethinking project management" body of knowledge, a more holistic and pluralistic understanding of project management. The project management should overcome the view of a discipline "with a series of learnable processes and skills that could be applied to any new project regardless of the industry, enterprise or society", with "predictable outputs based upon controlled inputs" (Gordon and Curlee, 2010:22). Moreover, Padalkar and Gopinath (2016b) recognise that a deterministic perspective dominates for knowledge management and learning in practitioners-oriented references such as the PMBOK (PMI, 2013a), calling for an integrative approach.

This thesis aims to contribute to the stream of literature on project complexity by enriching it with an organisational learning perspective. The findings are likely to advance knowledge on the issues of managing projects characterised by a level of complexity. Specifically, it acknowledges the importance of considering the emerging and dynamic features of complexity from the point of view of the experience accumulation and knowledge integration mechanisms of the teams when facing complexity at single and multiple projects level. The research framework, as described in the following paragraph, integrates themes and principles of complexity and organisational learning in projects to enrich the analysis. It also aims to provide methodological contributions by using a multi-level unit of analysis, which include the project teams and the overall organisation (i.e. a project-based one). This allows for the identification of empirical instances at both teams and overall organisation levels.

Finally, the thesis can provide some useful indications for the development of the Project Management discipline with reference to the definition, assessment and management of project complexity. The results of the research will be of importance for practitioners as it suggests actions and points of view to consider when dealing with the complexity of their projects, especially considering the point of view of the organisational process that takes place within projects (and across multiple projects, when an organisation is project-based or in general develops more projects to realise its strategic objectives).

I.4 RESEARCH FRAMEWORK

The study followed an iterative process of literature review and empirical research. After an exploratory investigation on definitions and concepts of project complexity in the project-oriented literature, the first phase of the study involved the conduction of a systematic literature on complexity in projects and in project management. The extensive – and growing – number of publications made project complexity one of the most important and controversial topics (Bakhshi et al., 2016) in the recent project-oriented literature, with the need for an in-depth investigation of the main debates, the still open questions and the consequent gaps requiring further enquiries, both from scientific and practitioners point of view. Therefore, carrying out a systematic literature review allowed to select and then analyse a sample of the major publications on the theme in the light of the main research topics concerning complexity in projects and in project management. The results of the review allowed to identify key issues and gaps, with an indication of potential future research directions, focusing on the methodological, theoretical and thematic issues.

Starting from the results obtained in the first phase of the research, we performed a literature review on the key issues of organisational learning in project environments, building on the wider literature on organisational learning and project-based organising. Deductive methods were used to identify the core theoretical constructs relating to complexity and organisational learning in project environments in the selected literature in order to guide the empirical research. Along with this line, prior assumptions and constructs provided a foundation (Glaser and Strauss, 1967) and helped to make sense of the emerging findings in the following empirical research.

Basing on the identified gaps from literature, an embedded case study was selected as research design. The choice of the research design was justified by the focus on two "how"-type questions investigating a contemporary, complex phenomenon, i.e. emerging features and organisational learning processes (Cook and Brown, 1999) within and across projects, not yet deeply investigated. The chosen case is one of the largest and most diversified companies in the shipbuilding industry. Being the global leader in the construction of cruise ships, a system integrator and an organisational and business structure mainly based on projects, this setting offered an extraordinary opportunity to study how organisations face the complexity of their projects from an organisational learning perspective. The identification of the unit (the project-based organisation) and the sub-units of analysis (the ongoing – not completed – projects at the time of the study, aimed at developing customised cruise ships with different specifications and for different customers). The inclusion of multiple cases as sub-units allowed getting a broad view of the project complexity and the project-based learning at the organisational level both within and across multiple projects, providing insights for both the research questions. The phase of data collection and analysis involved mainly inductive methods, driven by data, thus surfacing new concepts and generating new insights (Gioia et al., 2012) for the categories derived from the literature review. Finally, the results have been discussed at the light of the previous literature, and an interpretative framework of complexity and organisational learning within and across projects has been derived.

Figure I.1 summarises the research framework above described.

I.5 STRUCTURE OF THE THESIS

This dissertation consists of 5 main chapters, following this introductory section and before the concluding remarks. After introducing the aims and questions for the research, its potential relevance and the research framework detailing the scope and the approach adopted, this thesis proceeds as follows.

Chapter 1 discusses theory drawn from the project-oriented literature on the concept of complexity in projects and in project management. We report the descriptive and thematic findings and outline the main research gaps and potential future research directions according to these.

Drawing on part of the research gaps identified in the previous section, Chapter 2 review the literature and the underpinning theories on organisational learning in project environments, starting from the seminal works on organisational learning and the previous contributions on project-based organisations. Attention is drawn to theories that help address the research question, focusing on concepts that are built both in project-oriented literature and organisation studies.

In Chapter 4 the design and the methods used in this research are presented. The rationale at the base of the choice of the research design and methodologies adopted for data collection and analysis are described.

Chapter 5 outlines the empirical setting for the research and the findings of the study. The following Chapter 6 presents the discussion of the results in the light of the current streams of literature.

Finally, the concluding section presents the answers to the research questions and the theoretical and practical contributions made by this study. Limitations of the research are also discussed, with reference to opportunities for future research.

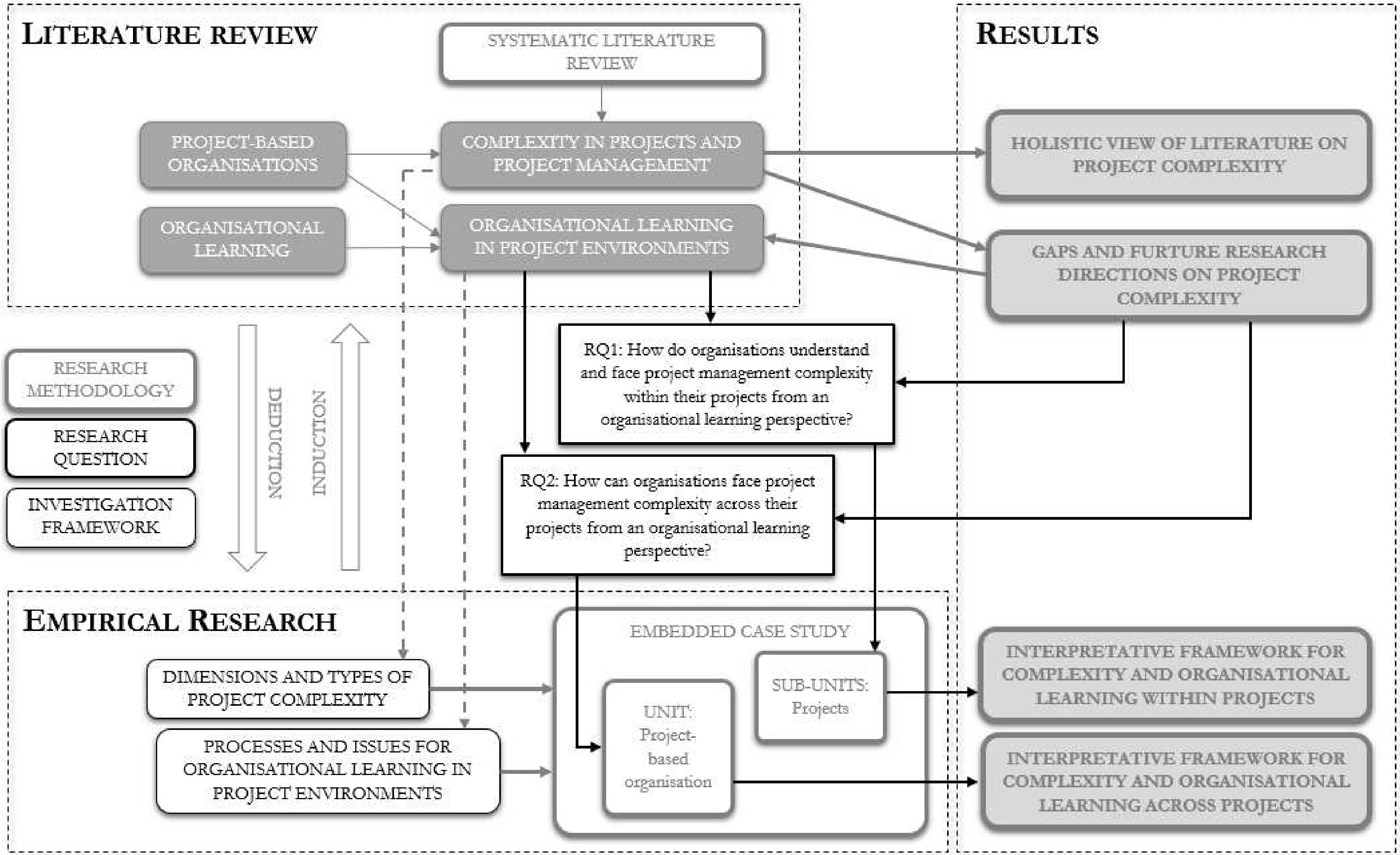


Figure I.1 – Research framework

Chapter 1. Complexity in Projects and Project Management

1.1 Complexity within the Project Management field

Project-based management is frequently associated with the management of complexity (Baccarini, 1996), as projects are widely used in modern society for the delivery of uncertain and complex tasks (Cicmil, 2005).

The concept of complexity has gained an increasing interest by scholars and practitioners in the last decades, becoming "one of the most important and controversial topics in project management" (Bakhshi et al., 2016: 1199). The extensive number of scientific publications and the positive trend of growth over the last two decades demonstrates the relevance of the concept in current scientific research (Bosch-Rekveldt et al., 2011). On the one hand, complexity appears among the main topics of the broadening scope of project management research according to Söderlund (2004). This is confirmed by Svejvig and Andersen (2015), who recognise complexity – and uncertainty – as one of the overarching categories covering the "rethinking project management" body of knowledge, a more holistic and pluralistic understanding of project management. On the other hand, there is still a lack of consensus among scholars on the definition of project complexity and what constitutes the concept itself (Luo et al., 2017).

Major reviews of the literature collocate project complexity in connection with the historical development and other key concepts of project management research and practice. Indeed, complexity is important to the project management process because it supports the identification of planning, procurement, coordination and control requirements, suitable project organisational forms and expertise inputs (Baccarini, 1996). Of the literature reviews identifying complexity among the main research issues in project management field, the scope and point of view on project complexity are shown in Table 1.1.

Analysing and comparing the contributions, we can argue that complexity has been frequently identified as one of the most interesting areas for research, especially for providing alternate perspectives and methods for the project management research and practice. Complexity in projects and in project management has been studied extensively in the last two decades. Despite that, little literature still focuses on non-determinism and theory building (Padalkar and Gopinath, 2016b; Winter et al., 2006) and still focuses on specific types of projects (Padalkar and Gopinath, 2016b), with the need for a multi-projects perspective (Söderlund, 2004b).

Table 1.1 – Points of view on complexity within the project management research

REFERENCE	AIM AND SCOPE OF THE REVIEW	POINT OF VIEW ON COMPLEXITY
Payne (1995)	▪ currently available literature on the management of simultaneous multiple projects ▪ identifying areas for further studies on the management of multi-projects	○ complexity – related to interfaces, controls and integration among projects – is identified as the most interesting area for studies aiming to improve the management of simultaneous multiple projects ○ the problems of complexity of multi-project management are worsened when organisations have to cope with differences of size, variety of skills required for the advancement of the project, and different degrees of urgency among the projects
Söderlund (2004b)	▪ project-related publications in major management and organisation scientific journals, with a focus on the International Journal of Project Management ▪ to analyse developments and perspectives of research on projects	○ increasing attention towards aspects of complexity in the management of multi-projects ○ need of new paradigms for managing complexity in the broader scope of project management research ○ importance of Complex Products and Systems (CoPS) in the functional structure of multi-projects firms
Crawford et al. (2006)	▪ articles published in the *International Journal of Project Management* and the *Project Management Journal* over the period 1994–2003 ▪ to provide a reference on the changing evolution of project management field	○ the influence of complex systems thinking has increased interested towards complexity and emergent properties
Winter et al. (2006)	▪ all the research material produced by Rethink Project Management (RPM) network over a 2-year period ▪ to define an inter-disciplinary research agenda for the RPM network	○ complexity (meant at all levels) of projects and programmes is the most discussed input from practitioners across all sectors ○ need to develop new models and theories about actual project management (including new ontologies and epistemologies) to assist practitioners in 'how' dealing with complexity ○ practitioners show an approach towards the complexity of projects that is firstly reflective and secondly pragmatic
Artto et al. (2009)	▪ 517 articles and 1164 project articles published in leading scientific business journals ▪ to identify theoretical bases and distinctive characteristics of programme and project management research	○ from a contingency perspective, complexity – together with uncertainty and novelty of projects and programmes – should be used more often as a moderator in developing more elaborate contingency frameworks for programme and project management

REFERENCE	AIM AND SCOPE OF THE REVIEW	POINT OF VIEW ON COMPLEXITY
Turner et al. (2013)	▪ publications on projects belonging to the nine schools of thought ▪ to group progress and trends of research on project management in management literature into nine major schools of thought; to identify relations among the schools and other streams of research	o complexity of projects is one of the themes in the 'modelling school', where the project management system is broken into its main elements and interactions between them, then integrated to obtain a full view of the total system o causes of project complexity are the increasing complexity of developed products and the tightening of timescales (citing Williams, 2002) o in the 'contingency school', an organisation's ability to manage complex new projects is related to the ability in remembering factors associated with its past successes
Svejvig and Andersen (2015)	▪ 74 publications from Rethinking Project Management (RPM) literature ▪ to identify and conceptualise categories and different perspectives of the current contributions for their integration and further expansion	o complexity and uncertainty are recognised among the main categories in the RPM literature o emergent alternative perspectives and theories to identify sources of complexity o need to consider complexity as an underlying argument for rethinking project management practice
Padalkar and Gopinath (2016b)	▪ 36 literature reviews on projects and 230 highly cited articles from their reference lists ▪ to identify and organise themes of past and current project management research and to elicit general trends	o project/process complexity is one of the emergent themes addressed by contributions with a perspective on non-deterministic aspects of the projects; low number of studies that focus on non-determinism and theory building o main themes for investigations on project complexity are: causes, contingencies, external social context, soft skills, frameworks for a specific type of projects (e.g. large engineering), methods for managing it o complexity and uncertainty are the main lenses of enquiry on risk management in projects o complexity in projects is recognised as one of the alternate perspectives for future research directions

The growing interest and the still open debate on the definition, conceptualisation and implications of complexity for project management research and practice have driven the need to explore comprehensively the present state of the literature on specific themes of project complexity. Recently, some authors (e.g. Bakhshi et al., 2016 and Kiridena and Sense, 2016) have published literature reviews on the theme in relevant academic journals. Table 2.2 summarises and compares the publications that reviewed previous literature on project complexity, highlighting the main focus and topics of investigation (e.g. conceptual definition or dimensions or influencing factors).

Most of these contributions focus on specific themes, specifically the conceptualisation and definition of project complexity, and do not explore comprehensively the research advancements. They provide a critical examination of how previous contributions conceptualise and operationalise complexity proposing additional categorisation (e.g. Kiridena and Sense, 2016). The number of papers considered in the analysis is high, due to the scope and the objectives of the review, while only Geraldi et al. (2011) limit the analysis on the "complexity of projects" research stream (while excluding the one on the "complexity in projects"). The only literature aimed at identifying future research directions is the recent one by Luo et al. (2017), however it is focused on the construction industry.

Table 1.2 – Literature reviews on project complexity

REFERENCE	METHODOLOGY	SAMPLE	MAIN CONTRIBUTION	MAIN FOCUS
Geraldi et al. (2011)	Systematic analysis	25 articles (journals)	The authors provide a typology of complexity of projects, identifying five dimensions – structural, uncertainty, dynamics, pace, socio-political – and relative attributes and indicators	Conceptual definition and dimensions of project complexity
Bakhshi et al. (2016)	Systematic analysis	423 papers (peer-reviewed journals)	The authors frame the evolution of the concept, the views (i.e. PMI, Systems of Systems, Complexity Theories) and the factors of project complexity	Theoretical background, conceptual definition and factors of project complexity
Kiridena and Sense (2016)	Systematic analysis	74 publications (project management literature) and 28 (complexity science)	They develop a hierarchically organised framework as a reference for project management practitioners for understanding the concept of project complexity. They identify the complexity dimensions (structural, interactional and dynamic) and the technical, environmental, organisational attributes from the literature in project management and complexity science	Definitions and dimensions of project complexity, and implications for project management practitioners
Padalkar and Gopinath (2016)	Semantic taxonomy analysis	58 corpus articles (top journals…)	They identify terms and differentiate the historical evolution of their associations to the two constructs of complexity and uncertainty in project management literature	Conceptual definition of project complexity
Luo et al. (2017)	Systematic analysis	74 articles (journals and conferences)	They trace historical evolution and future trends for research on complexity of construction projects in terms of influencing factors, impact on project performance, measurement methods and tools, management (risk management, management style, and adaptive capacity)	Factors of project complexity, impact on project performance, complexity measurement, complexity management

Basing on this analysis, a deep investigation of the still open questions on this theme and the consequent future research directions is missing.

1.2 PROJECT COMPLEXITY LITERATURE: STATE OF THE ART

Considering the growing trend in publications and the living interest on the topic of project complexity both from scholars and practitioners, the literature is varied and fragmented. It develops in a number of directions in terms of the topics discussed, the methodologies adopted, the contexts and the empirical settings analysed, the research questions and objectives, and so on. There is a need to deepen and provide a complete picture of the literature on complexity in projects and project management.

A systematic literature review was then conducted, aiming to identify the main topics of discussion and the relevant contributions and gaps on a scientific and practical point of view. The review process resulted in a total of 47 articles published in 17 peer-reviewed journals. The methodology of systematic literature review (Petticrew and Roberts, 2006; Tranfield et al., 2003) is described in Appendix A. All the records on the analysed contributions are summarised in Appendix B, while the descriptive and thematic results are discussed in the following sections. Finally, the literature review helped to identify directions for the research questions, further specified in the following Chapter.

While previous reviews were mainly focused on understanding and conceptualisation of the concept of project complexity, the analysis provided in this thesis aims to deepen the main streams and point of discussions addressed by scholars when dealing with complexity in projects and project management. This section explores and classifies the selected 47 articles according to criteria of year, journal outlet, research purpose, methodology and level of analysis.

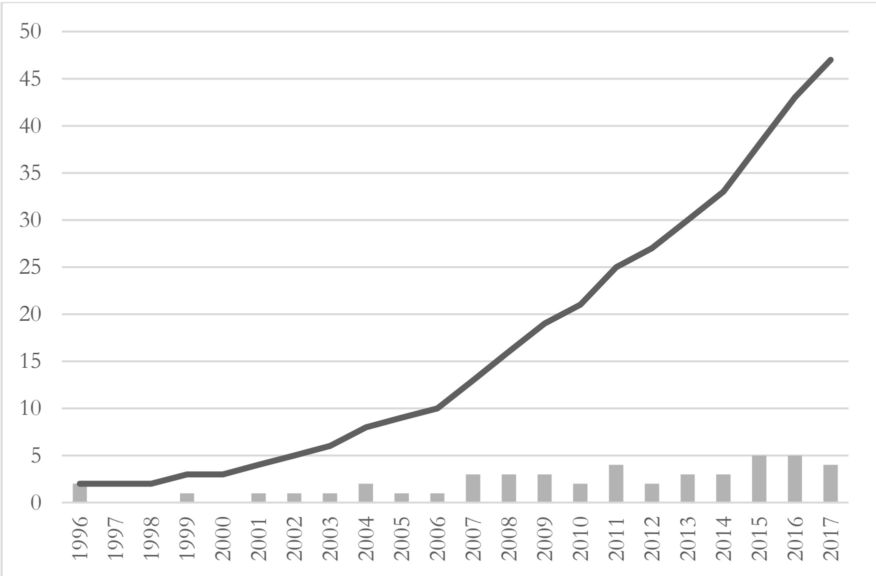


Figure 1.1 – Distribution of articles by year

The above figure shows the exponential growth in the number of publications on this topic, with a continuity from 2001. Indeed, main contributions for the possible insights from the exploration of the perspective of complexity in projects and project management and the further theory building have been the ones by Shenhar (2001) and Pich et al. (2002).

Focusing on the distribution by journal outlet, we can observe that more than half of the selected articles have been published in the two key journals for the project-oriented literature, i.e. *the International Journal of Project Management* and *Project Management Journal* (this latter constitutes also the reference for practitioners, being edited by the Project Management Institute). More than one publication appeared in two journals focused on the engineering and construction sectors (i.e. *Journal of Management in Engineering* and *Journal of Construction Engineering and Management*). This observation is corroborated by the fact that construction projects are widely recognised as being among the most complex ones (Baccarini, 1996; Luo et al., 2017). Finally, many publications in Management Science show the interest to deepen managerial issues linked to the complexity of projects, extending the project management discipline to the general management literature.

Table 1.3 – Distribution of articles by journal

JOURNAL OUTLET	#
International Journal of Project Management	20
Project Management Journal	7
Journal of Management in Engineering	3
Management Science	3
Journal of Construction Engineering and Management	2
Building research and information	1
Construction Management and Economics	1
Emergence: Complexity and Organisation	1
Engineering Project Organisation Journal	1
Engineering, Construction and Architectural Management	1
Information Technology and People	1
International Journal of Information Technology & Decision Making	1
International Journal of Managing Projects in Business	1
International Journal of Operations and Production Management	1
Kybernetes	1
Systems Research and Behavioral Science	1
Technology Analysis and Strategic Management	1
Total	*47*

Table 1.4 – Distribution of articles by research purpose and methodology

	METHODOLOGY							
RESEARCH PURPOSE	Literature review	Conceptual	Case study	Survey	Delphi method	Fuzzy AHP	Mixed methods	*Total*
Description	9%	11%	2%					*21%*
Exploration		6%		2%			2%	*11%*
Theory building		6%					2%	*9%*
Theory extension / refinement	2%	9%	15%		2%	2%	9%	*38%*
Theory testing			9%	6%			6%	*21%*
Total	*11%*	*32%*	*26%*	*9%*	*2%*	*2%*	*19%*	

Table 1.4 details the analysis of the methodological framework adopted, integrating the views of research purpose and methodology (Annarelli et al., 2016). The majority of the studies are conceptual, following the need for better structure definitions of dimensions of complexity or further extending the previously developed frameworks, covering essentially all the research purposes. Other studies mainly focus on case studies (26%), with a tendency towards theory extension or testing (15% and 9%) or mixed methods (using both qualitative and quantitative methods) as the topic of project complexity mainly requires an investigation of the settings (Cicmil

and Marshall, 2005) and a non-deterministic approach (Padalkar and Gopinath, 2016b). Few studies are aimed at exploration and theory building (respectively 11% and 9%).

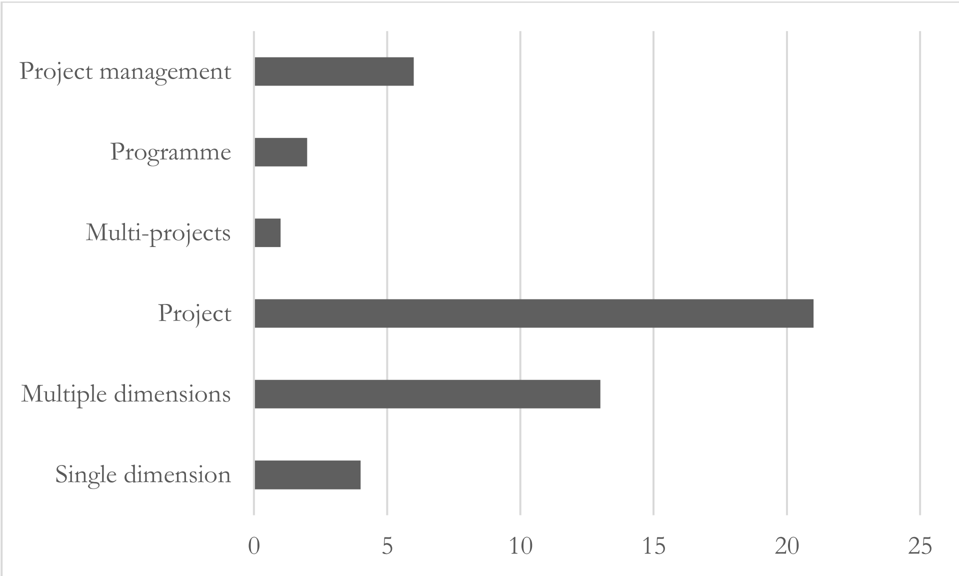


Figure 1.2 – Distribution of articles by level of analysis

Finally, Figure 1.2 shows how the majority of the papers (almost half of them) focus the analysis on single projects or the disaggregation of multiple dimensions of complexity (e.g. Geraldi and Adlbrecht (2007) with the definition of complexity of faith, fact and interactions), missing the potential to develop the analysis of dynamics and interactions in a multiple projects environment (as for example the specific case of the programmes, studied by Brady and Davies (2014) and Davies and Mackenzie (2014)).

1.2.1 A Holistic View of the Project Complexity Literature

Finally, the review allowed to identify the main research topics concerning complexity in projects and in project management (see Appendix B). Four fundamental themes were identified as follows:

- Understanding and characterising project complexity
- Measuring project complexity
- Relationship between project complexity and performance
- Practices and strategies to cope with complexity

While each theme seems to identify a specific line of enquiry and following debates, the thematic analysis revealed possible interdependencies between them. Figure 1.3 shows the proposed classification for the main themes under investigation with the possible interconnections, enabling to obtain a holistic map of the current research on complexity in projects and project management.

Understanding and characterising project complexity represents a first stage in a "complexity journey" (Maylor and Turner, 2017) and should start from a comprehensive overview of definitions, underpinning perspectives and theoretical lens and subsequent dimensions, types and determinants of it. Starting from this, the other two themes of investigation are the intervening steps, i.e. measuring the level of complexity and identifying (then developing) practices and strategies to cope with complexity. Finally, defining the relationship between project complexity and performance provide the basis for the managerial "response" (Maylor and Turner, 2017).

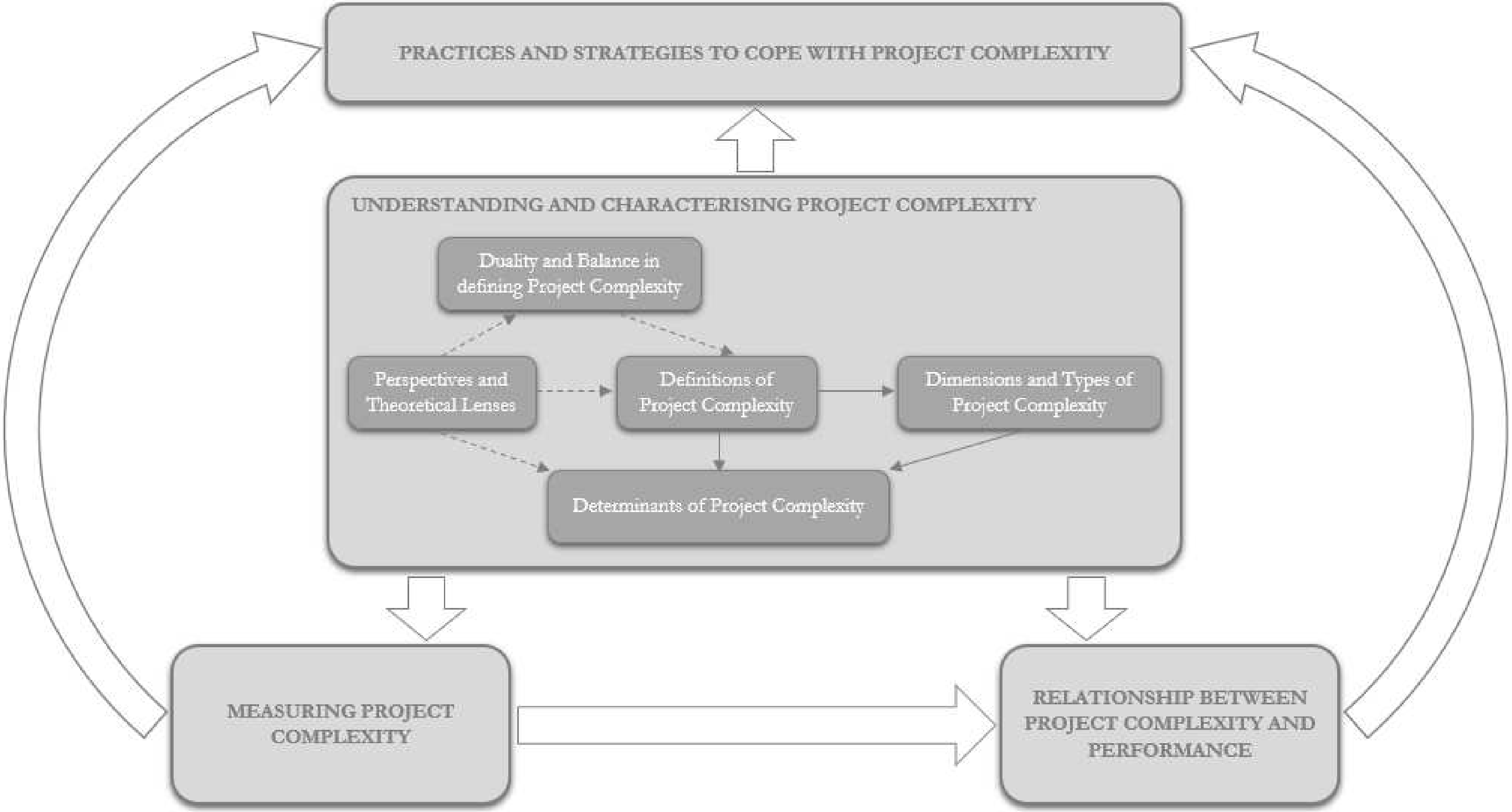


Figure 1.3 – A holistic view of project complexity literature

The next sections present the thematic results of the literature review, by discussing and comparing the selected papers according to the main topic area.

1.3 UNDERSTANDING AND CHARACTERISING PROJECT COMPLEXITY

The recent literature has focused prominently on the conceptualisation and assessment of project complexity. Several studies built on the insights from previous contributions and collected the perceptions of practitioners as sources of knowledge for the understanding of complexity in projects and project management. Their findings were then structured in frameworks or models, aiming to provide a reference for a qualitative assessment of the level of complexity of a project and distinguish among projects with high and low levels of complexity. Indeed, an understanding of project complexity enables to better support the management of projects, without necessarily assuming controllability or reducing the level of complexity (Bosch-Rekveldt et al., 2011). However, there is still a lack of consensus among scholars on the definition of project complexity and what constitutes the concept itself. This is mainly due to the fact that complexity is a term difficult to define and lacks clarity and widely acknowledged methods to assess and quantify it (Luo et al., 2017).

Numerous frameworks theoretically grounded and empirically validated are available in project management literature (Padalkar and Gopinath, 2016a). Focusing on a descriptive and qualitative analysis of project complexity, main topics of discussion have been: definitions, perspectives and theoretical lenses, dimensions and factors influencing or contributing to project complexity

1.3.1 Definitions of Project Complexity

Despite the growing number of studies on project complexity, a universal agreement on its definition and conceptualisation is still missing (Kiridena and Sense, 2016). The subjectivity and then the lack of consensus on the definition of project complexity has resulted in difficulty in understanding its concept (Lu et al., 2015; Qureshi and Kang, 2015; Vidal et al., 2011), the linkage with complexity theory (Aritua et al., 2009; (Cooke-Davies et al., 2007) and its effects on projects success (Gidado, 1996) or failure (Bosch-Rekveldt et al., 2011; Benbya and McKelvey, 2006; Brady and Davies, 2014; Williams, 1999).

The concept of complexity was firstly introduced in the early nineties, with the articles by Turner and Cochrane (1993), Baccarini (1996), Gidado (1996). In the following years, new and modified definitions, characteristics, taxonomies, and factors have been introduced, adding further ambiguity and inconsistency to cope with (Bakhshi et al., 2016; Kiridena and Sense, 2016). A standard definition of complexity that can be potentially applied to any kind of project is thus missing (Dao et al., 2017). Table 1.5 shows the main definitions of complexity in projects and in project management, by highlighting the recurring keywords. The following sections further explain the rationale at the base of the diversity within the proposed definitions, mainly due to the underpinning theories and assumptions, and a sort of "balance" between opposite conceptualisations.

Table 1.5 – Definitions of project complexity

		KEYWORDS								
REFERENCE	DEFINITION	Difficulty	Dynamics	Emergence	Numerous	Hierarchy	Interactions	Interdependency	Interfaces	Variety
Payne (1995)	It "relates to those aspects concerned with the multiple interfaces between the projects, the projects and the organisation, the parties concerned etc. It is also concerned with the controls used by management, and the choice of how much integration of the multiple projects is either desirable or practical."	•			•				•	
Baccarini (1996)	"consisting of many varied interrelated parts and can be operationalized in terms of *differentiation* and *interdependency*", where *differentiation* is "the number of varied elements" and *interdependency* "the degree of interrelatedness between these elements"				•			•		•
Gidado (1996)	"the measure of the difficulty of implementing a planned production workflow in relation to […] quantifiable managerial objectives […] without unnecessary conflict between the numerous parties involved in the process"	•			•		•			
Vidal and Marle (2008); Vidal et al. (2011)	"is the property of a project which makes it difficult to understand, foresee and keep under control its overall behaviour, even when given reasonably complete information about the project system."	•		•						
Geraldi et al. (2011)	"something that is experienced by project managers" as "[…] result of a number of factors or dimensions"; "include both "complicatedness" and theoretical complexity"	•		•	•					
Xia and Chan (2012)	"inherent characteristic of a project that results from its various interconnected parts"				•		•	•		•
Davies and Mackenzie (2014)	"defined in terms of the number of components, degree of interactions among them and the number of hierarchical levels in the system"				•	•	•		•	
Lu et al. (2015)	"consisting of many varied interrelated parts, and has dynamic and emerging features"		•	•	•		•	•		•
Bakhshi et al. (2016)	"an intricate arrangement of the varied interrelated parts in which the elements can change and evolve constantly with an effect on the project objectives"		•	•	•			•		•
	Total number of citations	*4*	*2*	*4*	*8*	*1*	*4*	*4*	*2*	*4*

We can observe a substantial agreement on the presence of numerous elements within the project, the interactions and the interdependencies among them, and their variety. The most recent definitions identified (i.e. Lu et al., 2015; Bakhshi et al., 2016) show a more interest towards the dynamics and the emergence of features and effects. The effects have been interpreted mainly in terms of difficulty in managing the projects by the previous studies (e.g. Vidal and Marle, 2008; Vidal et al., 2011).

Adding to this, scholars (e.g. Williams, 1999) acknowledge the difficulty of distinguishing between large projects and complex projects. Complexity has often been recognised as an umbrella term associated with interconnectedness and interfaces in project systems (Antoniadis et al., 2011; Geraldi and Adlbrecht, 2007). Complex projects are characterised by diverse, autonomous and independent parts that are connected to the other parts and systems, generating unexpected emergent properties (Bakhshi et al., 2016). Accordingly, a high level of complexity in a project implies the existence of more dependencies and interconnections to be structured in the project implementation and management. This results in an indeterminacy and uncertainty of their behaviour and reaction to changes in inputs (Williams, 1999).

1.3.2 Perspectives and Theoretical Lenses

Definitions and dimensions identified in the previous paragraphs build on different conceptualisations and underpinning theories. The difference between views and theories mainly contributed to project complexity in becoming 'one of the most important and controversial topics in project management' (Bakhshi et al., 2016). Cooke-Davies et al. (2007) highlight that different disciplines are investigating into the behaviour of complex dynamical systems. The complexity turn in project management research has focused on complex dynamic systems, revealing new insights and a paradigm shift which can be applied in project management to deal with the future challenges and requirements of the modern practice. Table 1.6 summarises the main features build from the analysis of different perspectives on this.

Table 1.6 – Features of project complexity from the theoretical perspectives

PERSPECTIVE OR THEORY	REFERENCE	MAIN CONCEPTS
Systems theory	Baccarini, 1996	Differentiation, interdependence
Contingency theory	Geraldi et al., 2011	Structural, uncertainty, dynamics, pace, and socio-political complexity
	Shenhar, 2001	Uncertainty, system scope
Vibration analysis and control (non-linear systems)	Antoniadis et al., 2011	Unpredictability, non-equilibrium, mutability
Complex Adaptive Systems (CAS)	Aritua et al., 2009	Simple and self-organised relationships, hierarchies
Complexity science or Complexity Theory	Bakhshi et al., 2016	Paretian and power-law distributions, edge of chaos, chaotic behaviour (tiny initiating events), scale laws, fractals, fitness landscape, contingency, control parameters
	Cooke-Davies et al., 2007	Butterfly effect, strange attractors, fractals, edge of chaos, patterns, dissipative structures, self-organisation, emergence, indeterminacy
	Jaafari, 2003	Openness, chaos, self-organisation, interdependence
	Kiridena and Sense, 2016	Structural, interactional and dynamic

Baccarini (1996) builds his definition of project complexity from systems theory. Specifically, the characteristics of differentiation and interdependence included in his definition of complexity can be applied to any dimension of the project management process, such as the organisation, the decision making and the environment. The systems view is adopted also by Geraldi et al. (2011), Shenhar and Dvir (1996), Shenhar (2001) and Davies and Mackenzie (2014), who build on the core concepts of contingency theory to characterise types of projects according to their complexity. The rationale at the base of the contingency domain is that different types of projects and contexts require different approaches, tools and management styles. Specifically, the majority of these scholars relate project complexity to the complexity of the product and/or outcome of the project, defining it in terms of dimensions of system scope and technological uncertainty. Basing on contingent factors, each type of project requires distinct (and right) choices on more elaborate formal organisational arrangements and project processes as the level of complexity of the outcome increases (Brady and Davies, 2014) or the context changes (Geraldi et al., 2011).

Aritua et al. (2009) ground on the theory of complex adaptive systems (CAS) in order to understand the management of multi-projects in the form of programmes or portfolios of interdependent projects, and its role in aligning projects to the overall strategy of an organisation. They argue that the challenges of a multi-projects environment can obtain relevant benefits by adopting a complexity theory mindset within the practice. According to this, programmes and portfolios can be viewed as a bundle of projects interconnected with simple, self-organised relationships that results in a complex adaptive behaviour of the multi-project system, with implications for the recognition of hierarchies between programmes and projects goals and the ability to adjust to feedback.

Antoniadis et al. (2011) apply the theory of vibration analysis and control systems to model the effect of the socio-organisational complexity, defined in terms of interconnections, and the project schedule performance. The observed relationship is a curve compared to an underdamped transient motion, where complexity characteristics can be viewed as 'dampers' in achieving the required outcomes in the project management process and sub-processes. Their results confirm the higher order and non-linearity of project management, showing that unpredictability, non-equilibrium and mutability are the characteristics of complexity that occur more frequently in constructions projects.

Many authors have drawn their understanding of project complexity on the key concepts from the complexity science literature. Indeed, the application of complexity theory to project research can provide a more holistic view of project management (Aritua et al., 2009) and improve the capability of professionals who manage complex projects (Thomas and Mengel, 2008; Whitty and Maylor, 2009). The integration of the key concepts from the mainstream complexity science literature brought an important contribution to advancing the understanding of project complexity (Kiridena and Sense, 2016; Svejvig and Andersen, 2015; Padalkar and Gopinath, 2016b). Cooke-Davies et al. (2007) derive the relevance of the key concepts and attributes of complexity identified in the domains of life sciences, physical sciences, and mathematics to project management theory and practice. Later, Bakhshi et al. (2016) integrate the concepts from the complexity theories with the Project Management Institute view (focusing on ambiguity and socio-political elements) and the System of Systems view, proposing the elements that integrate the three perspectives in characterising the complexity of a project.

1.3.3 Duality and Balance in defining Project Complexity

The first results of this literature review and other contributions (e.g. Geraldi et al., 2011, Floricel et al., 2016; Qureshi and Kang, 2015) evidence that the project management research on complexity tends to separate and balance the definition between (respectively):

- Complexity *in* projects and complexity *of* projects (or complex projects) (e.g. Geraldi, 2009; Geraldi et al., 2011)
- Objective (or prescriptive) and subjective (or perceived) conceptualisation (e.g. Vidal and Marle, 2008)
- Theory and practitioners (e.g. Bakhshi et al., 2016)
- Complexity as a positive or negative aspect (e.g. Vidal and Marle, 2008)
- Technological or technical and organisational or institutional domains (e.g. Baccarini, 1996; Lessard et al., 2014)
- Static or structural or detail and dynamic complexity (e.g. Davies and Mackenzie, 2014)

The distinction between the prescriptive (or objective) and the descriptive (or subjective) notions of complexity derives from the definition of complexity as an intrinsic characteristic of a system (i.e. a project) or resulting from the limitations of the human cognition (as a separate observer of the system) (Kiridena and Sense, 2016; Maylor et al., 2008; Vidal and Marle, 2008). The assessment of complexity in a certain project or phase is a subjective process by nature, as the perceived complexity strongly depends on the skills, available resources and previous experiences of the parties and stakeholders involved in a project (Bosch-Rekveldt et al., 2011; Dao et al., 2017). According to the capacity to understand, manage and keep under control the project system, its complexity is interpreted in terms of difficulty (Vidal et al., 2011).

Building on this, another distinction is between the contributions that build on the concepts from the complexity sciences and the practitioners-driven ones, based on the Project Management Institute view (Bakhshi et al., 2016). The description of projects as complex (and also) adaptive systems (e.g. Aritua et al., 2009) and the underpinning theories have been described in the previous paragraph. For example, complexity has been defined by practitioners as an attribute of a project management practice relating to its 'perceived ease of use' (Fernandes et al., 2015). In fact, people are used to reflecting on the events such as project complexity characteristics for their own benefit or exposure to them (Antoniadis et al., 2011). Gidado (1996) highlights that there are two perspectives of project complexity for practitioners: the managerial perspective, which defines complexity in terms of the planning of linking numerous elements to form a workflow, and the operative and technological perspective, which focuses on the difficulties of executing individual pieces of work. The managerial complexity, defined as 'project management complexity' is indeed a subset of the overall project complexity (Bosch-Rekveldt et al., 2011). Specifically, it relates to the influence on the perception of project management in terms of difficulty of executing or integrating the numerous parts of a project such as the internal team interfaces and the site logistics (Dao et al., 2017; Gidado, 1996), resulting in the difficulties associated with decision making and goal achievement (Maylor et al., 2008).

The subject of complexity has been linked both to technical and socio-organisational aspects. The non-technical aspects include the communication, the behavioural and social influences and interactions between people, organisations and the external environment (Antoniadis et al., 2011; Bosch-Rekveldt et al., 2011; Geraldi and Adlbrecht, 2007). The variations in the organisational or institutional precursors to complexity have a more significant impact on the project outcomes than purely technical aspects (Antoniadis et al., 2011; Lessard et al., 2014). For example, Nguyen (2015) shows that socio-political complexity is the most defining component of complexity in transportation construction. Nevertheless, both domains should be considered in the analysis as they are characterised by different structures and dynamics (Lessard et al., 2014).

The following Paragraph 1.3.4 further details the analysis on technological, organisational, structural, dynamic complexity and the other dimensions of complexity identified in the reviewed literature.

1.3.4 Dimensions and Types of Project Complexity

Several studies made an attempt in disaggregating the definition of project complexity and investigated specific attributes, types or categories of project complexity (Dao et al., 2016; Luo et al., 2017). As a consequence of the lack of consensus on the definition of project complexity, the exploration of its components resulted in several conceptualisations. Specifically, scholars refer to types, dimensions, characteristics, aspects (Kiridena and Sense, 2016).

Table 1.7 summarises the dimensions and the types of project complexity identified in previous literature. In this analysis, *dimensions* are defined as the attributes (Geraldi et al., 2011) in which project complexity can be operationalised, basing on definitions provided in Paragraph 1.3.1. The *types* are defined in connection with the project aspects under investigation while measuring the project complexity. In many cases, studies presented different terms with similar definitions and contents; in others, researchers used the same or a similar terminology for defining different aspects of project complexity. For the latter, all the definitions identified in the literature review are reported.

Geraldi et al. (2011) reconstructed the historical development of the concepts and dimensions of project complexity in scientific literature and found out that, on the whole, authors don't deliberately build their work on previous frameworks. We can argue that there is a general consensus on two categories as regards the types of internal project complexity, i.e. the organisational complexity and the technological complexity (Baccarini 1996; Bosch-Rekveldt et al. 2011; Lessard et al., 2014). Technological complexity in a project is mainly influenced by product and tasks complexity (Turner and Cochrane, 1993; Williams, 1999) An additional dimension groups the aspects of the environment outside the project system, i.e. the environmental (Bosch-Rekveldt et al. 2011; Kiridena and Sense, 2016) or socio-political (Geraldi et al., 2011) complexity. This includes, for example, the market and competitive settings, the political and regulatory realm, the interactions with the other systems (e.g. project stakeholders).

A further consideration is required when talking about complexity and uncertainty. We can still find a well-defined separation between two streams of research: 1) complexity and uncertainty as distinct (but interrelated) concepts, and 3) uncertainty as a dimension or component of complexity. According to the first group of scholars, uncertainty is more often associated with risks rather than complexity (Dao et al., 2017). Among them, Sommer and Loch (2004) separate complexity from unforeseeable uncertainty, i.e. the uncertainty linked to the limits of the available knowledge that make the decision maker unable to recognise the relevant variables and their relationships (the so-called "unknown-unknowns" or "unk-unks"). Finally, many scholars investigate uncertainty as a dimension of complexity. Gidado (1996) identifies uncertainty factors originating from within the performed tasks, the environment and the resources employed in projects as one of the key components of complexity. These factors include the lack of uniformity of work (material and teams) and complete specification for the activities to be executed, the unfamiliarity of the inputs and environment by management, the unpredictability of the environment. These structural or know uncertainties can be avoidable through a reduction of complexity (Giezen, 2012), as complexity includes and links to the perception of uncertainty (Geraldi et al., 2011). Conversely, Bakhshi et al. (2016) argue that unfamiliarity and lack of knowledge are not associated with project complexity. In their TOE framework, Bosch-Rekveldt et al. (2011) decline the generic term uncertainty in "uncertainty of methods" and "unclarity of goals" among the factors contributing to project complexity from a technical perspective.

Table 1.7 – Dimensions and types of project complexity

DIMENSION	DEFINITION
Organisational complexity	complexity of organisational structure divided in (1) vertical and horizontal differentiation and (2) degree of interdependency between project organisational elements (Baccarini, 1996)
Structural complexity / uncertainty	concerned with the underlying structure of the project (Williams, 1999) refers to "arrangement of components and subsystems into one overall system architecture" (Brady and Davies, 2014) based on the attributes: size (or number), variety and interdependence (Geraldi et al., 2011) "gives a static, or snapshot, view of the project and its environment, comprising five dimensions: mission, organisation, delivery, stakeholders, and team" (Maylor et al., 2008)
Technological complexity / uncertainty	defined in terms of (1) differentiation and (2) interdependencies between tasks, technologies and/or between inputs (Baccarini, 1996) Associated with the degree of using new (to the company) versus mature technology within the product or process produced (Shenhar, 2001)
Technical complexity	three-fold concept: the variety of tasks, the degree of interdependencies within these tasks, and "the instability of the assumptions upon which the tasks are based" (Jones, 1993 from Williams, 1999)
Uncertainty	the constituent dimension of project complexity (Williams, 1999), linked to unknowns, variables to predict and manageability of the project and the planning (Giezen, 2012) "relates to both the current and future states of each of the elements that make up the system being managed, but also how they interact, and what the impact of those states and interactions will be" in terms of novelty, experience, and availability of information (Geraldi et al., 2011) difficulties of task performance (Baccarini, 1996)
Dynamic complexity / Dynamics	"addresses the unpredictable situations and emergent events that occur over time, which are associated with interactions among components of a system and between the system and its environment. Dynamic complexity is therefore associated with different types of uncertainty influencing the progress of a project" (Brady and Davies, 2014) refers to changes in projects and in the relationships among components within a project and between the project and its environmental context over time, e.g. changes in specifications, in management teams, or in suppliers (Geraldi et al., 2011)
Pace/flux and change	"refers to the rate at which projects are (or should be) delivered" and includes the temporal aspects (speed) of project complexity (Geraldi et al., 2011; (Cicmil and Marshall, 2005)
Size / System Scope	"there are different hierarchies within a product or a system with different levels of design and managerial implications" (Shenhar, 2001) Number and largeness
Socio-political / Institutional complexity	"emerges as a combination of political aspects and emotional aspects involved in projects" linked to the management of stakeholders (Maylor et al., 2008) and the interactions between people and organisations (Geraldi and Adlbrecht, 2007) "stems from interactions with the management systems of parent organisations, stakeholders and broader networks of interested organisations, and political and regulatory bodies" (Floricel et al., 2015) "including its environment and project organisation, is related to the nature, scope, and environment, where needs and expectations of the project are met" (Bakhshi et al., 2016)
Belonging	"each complex project consists of autonomous and independent parts and different structures that belong to the same project and are connected to the other parts and systems in the project" (Bakhshi et al., 2016)
Diversity	"can be defined as distinct element or quality in a group—the variation of social and cultural identities among people existing together in the project" (Bakhshi et al., 2016)

1.3.5 Determinants of Project Complexity

Further to the lack of consensus on the definition and dimensions of project complexity, scholars introduced a wide range of terms in describing its sources and attributes (Padalkar and Gopinath, 2016a), achieving relevant overlaps and often ambiguities (Kiridena and Sense, 2016). Both conceptual and empirical studies (e.g. Gidado, 1996; Kiridena and Sense, 2016; Liu et al., 2017) analysed previous contributions literature and collected the perceptions of practitioners in order to identify complexity factors in projects. Understanding and mapping the sources of project complexity has been demonstrated being a valuable help for practitioners to design efficient project team's configurations, adopt appropriate project management processes and tools, and improve organisational capabilities and leadership skills to deal with the challenges in managing projects induced by complexity (Antoniadis et al., 2011; Geraldi et al., 2011; Gransberg et al., 2013; Vidal and Marle, 2008). Along with this line, several contributions provide taxonomies or frameworks summarising drivers and categories of factors.

Gidado (1996) distinguish two categories of sources of complexity, i.e. the ones that are inherent to the operation of individual tasks (e.g. the roles and the resources employed) and the ones relating to the sequencing of the various operations in the workflow (e.g. the rigidity of sequence between the operations, and the overlap of stages or elements that causes additional effects). Bosch-Rekveldt et al. (2011) propose the Technical, Organisational, and Environmental (TOE) framework for characterising the complexity of engineering projects. They group a total of 50 elements contributing to project complexity under the categories technical (related to goals, scope, tasks, experience, and risk), organisational (related to size, resources, project team, trust, and risk), and environmental (related to stakeholders, location, market conditions, and risk). Liu et al. (2017) trace a timeline of previous contributions on project complexity and their interrelationships, by identifying commonalities, differences and relationships between influencing factors (e.g., interdependency, uncertainty factors, and organisation interactions) and complexity categories. Bakhshi et al. (2016) integrate different schools of thoughts to identify the most cited factors of project complexity. They show that the dimension of project context includes the higher number of factors, whereas project diversity and size dimensions consist of many factors that had been cited by the majority of the studies. Dao et al. (2017) identify twenty-two attributes (measures by thirty-four indicators) to be used to describe and measure the level of complexity of a project, limiting their analysis to the complexity related to managing projects (and excluding projects physical features such as materials and technologies).

The majority of these frameworks are both theoretically grounded and empirically validated (Padalkar and Gopinath, 2016a). A deeper analysis of factors influencing or contributing to project complexity goes beyond the aims of this research. The above findings highlight the importance of determining the elements that make a project complex and considering their structural or dynamic nature (Williams, 1999) and foremost their interdependency with one other and at the same time with the environment in which they are collocated (Gidado, 1996). Some scholars (e.g. Nguyen et al., 2015; Luo et al., 2017) criticise previous research as it tends to disaggregate the elements contributing to complexity within bounded categories, resulting in classifications that are not consistent. Indeed, complexity dimensions and factors are frequently independent (Geraldi et al., 2011). Along with this line, Luo et al. (2017) map the relationships among the influencing factors and their categories linking studies on complexity in construction projects. Bosch-Rekveldt et al. (2011) define hierarchies of elements by considering different coarse-grained levels of aggregation.

Table 1.8 summarises the contributions that investigated factors, attributes and elements contributing or influencing project complexity.

Table 1.8 – Studies on determinants of project complexity

REFERENCE	CLASSIFICATION OF DETERMINANTS
Vidal and Marle (2008)	The authors develop a framework that classifies project complexity factors according to four families – project size, project variety, interdependencies, and context-dependence.
Bosch-Rekveldt et al. (2011)	They build a framework that consists of technical, organisational and environmental elements contributing to project complexity as basis for the assessment of complexity in engineering projects
Lessard et al. (2014)	They propose the 'House of Project Complexity' as theoretical framework dividing factors contributing to project complexity in inherent features (technical and institutional), architectural constructs and arrangements, emergent properties
Chapman (2016)	The author identifies six sources of project complexity from literature – project governance, project initiation, complexity dimensions, assurance processes, evolving PM maturity – to build and apply a complexity framework for transportation projects
Dao et al. (2017)	Main attributes and indicators to be considered when measuring (qualitatively) the level of complexity of a project and distinguish between high and low level of complexity

1.4 MEASURING PROJECT COMPLEXITY

Researchers have increasingly recognised the importance of complexity measurement in project diagnosis and proposed models for measuring project complexity from multiple perspectives and adopting different methods. Once project complexity becomes measurable, the acceptable limits for an efficient managerial and operative effort in the project can be established as the threshold of complexity (Gidado, 1996). Nevertheless, the lack of consensus on the definition and conceptualisation of complexity in projects resulted in limiting the operationalisation of it (Bosch-Rekveldt et al, 2011; Chapman, 2016; Lessard et al., 2014; Padalkar and Gopinath, 2016a). The variety of conceptualisations of project complexity requires the use of highly subjective methods (Gidado, 1996) and there are concerns about the reliability of the evaluation and the applicability of the few proposed models (Vidal et al., 2011).

In this section, articles referring to complexity operationalisation or measurement without proposing a new or tested model of complexity are not analysed. For example, Baccarini (1996) proposes that project complexity should be operationalised in terms of differentiation and interdependence of its components, but he doesn't translate it into a quantifiable indicator. Nassar and Hegab (2006) developed a complexity measure of project schedules, basing on the degree of interrelationships between the activities in the schedule of a project. While the schedule network of a project may contribute to project complexity, measuring it is different from the complexity measure of the project. Gidado (1996) establishes a numerical equation of project complexity as a direct relationship with the estimated production time and cost, as resulting from the influence of one or more components of complexity, but the main contribution of the article lies in the assessment of project complexity.

Basing on bibliographic analysis, Qureshi and Kang (2015) define a structural equation model; it includes exogenous and endogenous variables and their connections as making a project difficult to understand, to foresee and to keep under control. Among mathematical models, Vidal et al. (2011) apply the analytic hierarchy process (AHP) and formulated a project complexity measure model to assist the project managers in the decision-making process. Nguyen et al. (2015) employ the Fuzzy Analytic Hierarchy Process (AHP) method to determine weights of the components of complexity to be included in a complexity index.

1.5 Relationship between Complexity and Performance

A number of studies have investigated the influence of complexity on project performance and objectives in terms of time, cost and quality. Specifically, the following discussion addresses the contributions that investigated the relations with performance and the broader definition of project success, then including the effects after the project completion. Scholars agree on the fact that without proper management strategies, complexity impacts negatively project outcomes (Dao et al., 2017).

Gidado (1996) shows that a project is defined 'complex' when the difficulty of managing and executing it influence one or more of the managerial objectives focused towards project success. Among the first studies, Baccarini (1996) argues that complexity affects the objectives of time, cost and quality, and a higher project complexity involves greater time and costs in a project.

Antoniadis et al. (2011) find that the project schedule performance curve follows an "underdamped transient motion", as after an initial drop in performance the number of complexity characteristics causing delay are gradually reduced and corrective actions are taken to overcome problems. Focusing on the complexity of the interconnections caused by the social interfaces and the boundaries between the various project teams (e.g. project teams structuring and selection, expertise, management style adopted), they highlight the need for organisations for improving the speed of response, reducing the wasted effort and developing measures for controlling and acceptance of change in order to minimise the effect of complexity of interconnections. Floricel et al. (2016) have studied effects of strategies dealing with new and existing knowledge on performances.

Table 1.9 outlines the differences in the type of performance considered and relationship with project complexity.

Table 1.9 – Studies on the relationship between project complexity and performance

Reference	Performance	Relationship / Effect		
		Negative	Positive	Other
Antoniadis et al. (2011)	Duration (schedule)			•
Carvalho et al. (2015)	Project success (cost, schedule and margin variation)	•		
Floricel et al. (2016)	Completion	•		
	Innovation		•	

1.6 Practices and Strategies to Cope with Complexity

Despite the growing research aiming to better understand and conceptualise project complexity, there is still ambiguity on how relating it to project practice (Geraldi et al., 2011; Kiridena and Sense, 2016; Vidal and Marle, 2011). Many authors (e.g. Kiridena and Sense, 2016; Williams, 1999) have highlighted the need for more effective processes and tools to deal with the increasing complexity of the projects, aiming to focus the deployment of appropriate resources and develop targeted, advanced skills for the success of the project. The management of project complexity is still in the early stages of development as a new theory within the project management field (Luo et al., 2017).

This section analyses the approaches that have been investigated, described and adopted in the reviewed literature for dealing with project complexity and ensuring the successful delivery of a project. Several studies have made proposals in terms of managing project complexity and its effects. In fact, the management of project complexity can be identified as the "final goal of project complexity research" (Luo et al., 2017: 04017019-7). Other studies have focused on the enactment of new or modified approaches when managing projects with complexity. As distinct types of projects require a different management approach (Shenhar, 2001), practices and strategies adopted in the management process should be made contingent upon the specific level of complexity in the project. The use of managerial functions appropriately balanced to the measure and type of project complexity from the front-end phase can influence the effects of complexity on project performance and success (Gidado, 1996; Bosch-Rekveldt et al., 2011).

Main approaches were identified as project managers competencies and training, decision making, integration and risk management.

Project managers training. There is the need of identifying levels of training and available tools to educate project management practitioners and to enable them to cope better with the increasing complexity and uncertainty in project environments (Antoniadis et al., 2011; Thomas and Mengel, 2008). The understanding of how project complexity affects project management processes (and relative sub-processes) would enable project managers to take precautionary steps at the appropriate time in order to successfully and satisfactorily manage projects (Antoniadis et al., 2011). Whitty and Maylor (2009) identify the core competencies of project managers as reflective personal skills, competencies and thinking processes

Decision making. Sommer and Loch (2004) discuss the choice of two approaches to manage innovation projects with complexity, i.e. *selectionism* and *trial and error learning*. By modelling a project as a performance function, they demonstrate that the trial and error learning is a more robust approach than selectionism. Anyway, learning can require prohibitive costs and a cost comparison should be done basing on the available trials for innovation. In the decision-making process, the interaction between the fidelity of the trials, the complexity and the unforeseeable uncertainty of the project should be considered and modelled as not intuitive. Moreover, results show that the dimension of the interaction has more damaging effects on project performance (i.e. quality of the final solution) than the complexity due to the system size.

Integration. Dealing with differentiation and interdependence requires managing the projects by integration, defined in terms of coordination, communication and control (Baccarini, 1996). Building on both early research, Davies and Mackenzie (2014) argue that organisations should develop a systems integration capability to deal with the interdependence and change of complex projects. This allows decomposing a project into clearly defined components and interfaces.

Risk management. Project complexity is frequently associated with project risk, as related to the uncertainties due to the unknown around a project (Dao et al., 2017). Vidal and Marle (2008) show that modelling complexity can support the risk management in a project, as complexity is considered a source of risk.

1.7 MAIN GAPS AND FUTURE RESEARCH DIRECTIONS

This section discusses descriptive and thematic findings of the literature review by highlighting the main literature gaps and future research directions. Aiming to enrich the discussion in the light of the ongoing debates, it integrates the results of the other literature reviews, included the ones on the broader project management field (discussed in Paragraph 1.1). Table 1.10 summarises main gaps and point of discussions on the selected papers, with the subsequent possible future research directions. These are then discussed below the table.

Table 1.10 – Literature gaps and future research directions

TYPE OF ISSUE	THEME	RESULTS FROM LITERATURE REVIEW	
		Literature Gaps	**Future Research Directions**
Methodological issues	Research purpose and methodology	• Many descriptive and theory testing • Need for theory building	• Exploration • Theory building
	Level of analysis	• Few multi-projects settings • Connections with other projects not considered	• Consider projects in their historical and contextual development • Example: project-based organisations
Theoretical issues	Theoretical perspectives	• Awareness of definition of project complexity	• Clarify underpinning theories
Thematic issues	Understanding and characterising project complexity	• Need to better connect dimensions (separation) • Underpinning theories • More attention to dynamic properties, e.g. learning	• Insights from other theories, i.e. organisational studies • Main focus on interfaces and dynamics
	Measuring project complexity	• Focus on positivist approach or based on practitioners' opinions	• Integrate objective and subjective measures
	Relationship between project complexity and performance	• Less attention to long-term perspective • Less attention to contextual variables • More attention to complexity as mediating variable	• Consider evaluation of effects also at the end of the project • Consider contextual settings (e.g. project-based organisations)
	Practices and strategies to cope with complexity	• Confusion between management of complexity and practices and strategies form complexity management	• Consider evaluation of effects also at the end of the project • Consider contextual settings (e.g. project-based organisations)

From a methodological point of view, there is still confusion and overlapping among terminologies, therefore previous contributions have mainly focused on conceptualising, but there is a need for exploration and theory building. Along with this line, Padalkar and Gopinath (2016b) argue that "theory building in project management requires the adoption of the non-deterministic perspective, i.e. addressing the variability in project phenomena, and employing the appropriate theoretic and methodological approaches" (Padalkar and Gopinath, 2016b: 1316).

As regards level (or unit) of analysis, we identified the need for a perspective on factors and dimensions of complexity in a multi-project environment, or in general, considering the interconnections of the projects to their context.

Focusing on understanding and characterising project complexity, Kiridena and Sense (2017) and Kapsali (2013) suggest that alternative perspectives in the literature on how to best understand and therefore manage project complexity can be justified with the notion of "equifinality" in open systems, where possible multiple means exist for achieving the same end. Moreover, there is a need to better focus on the emerging and dynamic properties of the project system (e.g. self-organisation), as they are considered more critical than the structural aspects (e.g. scale and interconnectedness) within the major underpinning theories such as the systems theory and complexity science literature (Kiridena and Sense, 2016). Understanding of project complexity can, even more, benefit from a holistic view and a comparison with systems theory and complexity science literature. As regards factors, while being criticised as not consistent (Nguyen et al., 2015; Luo et al., 2017), the frameworks developed for the assessment of complexity from its influencing factors enable to create a complexity 'footprint' (Bosch-Rekveldt et al., 2011: 738) in a specific project or phase. The identification and mapping of several complexity drivers will enable the consideration of specific means and approaches for managing the effects of complexity to the project management processes from its characteristics (Antoniadis et al., 2011). Nevertheless, they risk being limited in scope if not properly applied, by considering the context-dependency, dynamic and emergent behaviour of complex systems throughout their evolution. For this reason, each framework should consider the contingent context of the application (Lessard et al., 2014). In the attempt to reconcile the diverse contributions, project management scholars should mention complexity by clarifying what kind of complexity it is (Shenhar and Dvir, 1996) and defining what level of complexity it is dealing with (Baccarini, 1996).

As regards measurement, we agree with Luo et al. (2017), who argue that "it is necessary to strengthen the attention on how to manage and control project complexity and carry out quantitative analyses on the different types of complexity for informing better management decisions."

CHAPTER 2. ORGANISATIONAL LEARNING WITHIN AND ACROSS PROJECTS

2.1 ORGANISATIONAL LEARNING IN PROJECT ENVIRONMENTS

Among the future research directions for deepening our knowledge on project complexity, Chapter 2 of this thesis outlines a literature gap on the emerging features of project complexity, such as learning. Basing on this, this section focuses on and studies the ongoing research on project-based learning, in order to identify the terminologies used to conceptualise it, the present definitions, the explored contents and the constituent elements. In fact, the considerations derived from the analysis of Chapter 2 are not sufficient and exhaustive as the review responds to more general objectives (i.e. the analysis of the current streams of research of project complexity) and mainly focuses within the project-oriented literature.

Projects are widely recognised as being "arenas of knowledge formation and learning" (Ahern et al., 2014:1427) and then a source of innovation (Gann and Salter, 1998; 2000). Consequently, they should be framed as a learning process, requiring interdependency and frequent communication (Edmondson and Nembhard, 2009). Organisational learning in project environments is affected by specific context conditions (Bartsch et al., 2013; Grabher, 2002; Koskinen, 2012). Moreover, it becomes a key strategic performance driver in the so-called project-based organisations or project-based firms (Blindenbach-Driessen and van den Ende, 2006; Brady and Davies, 2004; Söderlund, 2004a), i.e. the organisational structures where most or all business activities are carried out in the form of projects (Hobday, 2000). Indeed, prior and current projects can generate valuable experiences and new knowledge that can be applied in similar and future projects, leading to an improvement of the future performance (Brady and Davies, 2004).

As project-based learning (or learning in or from projects) is defined as a form of organisational learning, this theoretical section builds from both project-oriented literature and organisational studies to provide an appropriate theoretical basis and the scope boundaries for the development of the empirical research. The aim is to consolidate the theoretical assumptions underpinning the rationale below this study, building on the wider literature on organisational learning. Concepts and key issues of organisational learning are identified from seminal works and literature reviews belonging to organisation studies. The subsequent investigation outlines definitions and implications of organisational learning within multi-project environments as the project-based organisations, reviewing the contributions in the project-oriented literature. Project management research has frequently integrated models and concepts from other disciplines, with a caution in applying theories to the contextual nature of projects (Smyth and Morris, 2007). Figure 2.1 summarises the research fields and the concepts considered in the following analysis.

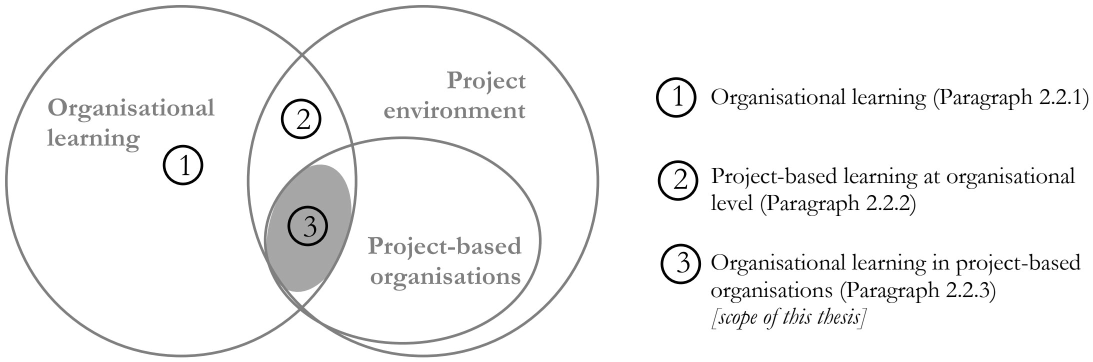


Figure 2.1 – Domains of organisational learning in project environments

The next section outlines the main definitions and issues raised by scholars with regards to organisational learning.

2.2.1 Definitions of Organisational Learning

Over the last five decades, there has been a growing interest of scholars and practitioners in the process of learning in and by organisations, i.e. organisational learning. The flourishment in thousands of contributions both at the theoretical and empirical levels reflects the recognition of organisational learning as a critical source for sustaining the success of a firm on the long-term (Argote, 1999; Argyris and Schön, 1978; Levitt and March, 1988) and the competitive advantage in dynamic environments (Zollo and Winter, 2002). This remark is strictly linked to the knowledge-based view of the firm, where knowledge is conceived as the most strategically significant and primary productive resource of the firm (Eisenhardt and Santos, 2002; Grant, 1996). According to this theoretical foundation, the creation, acquisition, store and deployment of knowledge, both in its tacit and explicit forms (Nonaka and Takeuchi, 1995), are fundamental organisational activities (Grant, 1996) for the operational functioning of the firm (Zollo and Winter, 2002).

The first appearance of publications on organisational learning dates back to the late 30s, with the introduction of the "learning curve" concept in the study of production costs in the airline industry. The learning curves were found at both individual and group level (Argote, 1999), mainly focusing on the definition of learning as a result of the repeated execution of similar tasks (Zollo and Winter, 2002). The concept of organisational learning was then further developed in the late 50s, partly influenced by the cybernetics (Shore and Zollo, 2015). Following studies have integrated and developed many different theories and concepts of organisational learning and its application (Mitleton-Kelly and Ramalingam, 2011).

In their seminal book *A Behavioral Theory of the Firm* (1963), Cyert and March advance a more general theory of organisational learning as part of the broader decision-making processes. They view organisations as adaptive systems, with possibilities of adaption in goals or preferences, performance criteria or environmental events to which they pay attention, and in the methods used for seeking and classifying information and alternatives. Organisational learning is thus perceived as a collective, adaptive change process that is influenced by the past experience in its creation and supported by organisational memory (Huber, 1991; Nonaka and Takeuchi, 1995). Later, Fiol and Lyles (1985) clarify the difference between organisational learning and organisational adaptation, showing that an only change in behaviour doesn't necessarily imply learning (Huber, 1991). Indeed, their definition of organisational learning refers to the process of improving actions as a consequence of reflection on new knowledge and understanding, then resulting in a change in cognition.

Cangelosi and Dill (1965) conceptualise learning as an adaption resulting from the overcoming of the threshold level of three kinds of stress: the *discomfort stress* that results from the complexity of the environment in terms of time, energy and ability that groups can expend understanding it, and of the uncertainty relative to the ability to forecast the future; the *performance stress* that is connected to the sensitiveness of an organisation to success or failure and is due to the outcomes of previous decisions, changes in preferences or aspiration levels, incentives, and challenges related to the newness of tasks for management; the *disjunctive stress* that takes place when there is a divergence in the individuals and subgroups adaptation that overcomes the expected extent to which various activities should be coordinated and the tolerated amount of conflict and disorder. Within this theoretical foundation, learning doesn't proceed on all levels at the same time and can occur more frequently and in smaller increments, or abruptly.

Argyris and Schön (1978) introduce the concept of "learning organisation" and describe organisational learning as a process mediated by the collaborative inquiry of its individual members. Each individual brings changes into the organisational practice by detecting and correcting errors from experience, and then embedding the results of their inquiry in media such as private images and shared maps of the organisation. They recognise that only individuals can act as agents, reflecting on behalf of the organisation. According to Senge (1990) as well, organisations learn through learning individuals who continually expand their capacity to create knowledge and patterns of thinking. Learning is defined as a process that results in changes of belief, attitude or skill and mainly concerns internalisation and acquisition of knowledge. As the members learn through shared action, the process is closely linked with the disciplines of building a shared vision and developing individual skills. Within his book *The Fifth Discipline: The Art and Practice of the Learning Organisation* (1990), Senge emphasizes the skill area of systems thinking as it helps to recognise patterns and interdependencies in the effort to understand the increasingly dynamic and complex reality.

Huber (1991) mainly focuses on the processes contributing to organisational learning, assuming that "an organisation learns if any of its units acquires knowledge that it recognizes as potentially useful to the organisation […] even if not every one of its components learns that something" (Huber, 1991: 89). According to Argote (1999), Argote (2011) and Argote and Miron-Spektor (2011), organisational learning occurs when an organisation acquires experience, which can be measured in terms of the cumulative numbers of task performed and in terms of both successes and failures. The individuals, with the routines and the transactive memory systems, become part of the variety of repositories in which knowledge could be embedded. This definition includes both the organisational 'knowledge' (which is static and *about* the tangible world) and the organisational 'knowing' (as part of the situated and ongoing action of one or more individuals while interacting with the context), drawing on the concepts by Cook and Brown (1999) and Orlikowski (2002). Indeed, Cook and Brown (1999) extend Nonaka and Takeuchi's model (1995) by arguing that each form of knowledge (i.e. tacit and explicit, individual and at the group – or organisational – level) should be used in parallel and as an aid in acquiring the other.

The different theoretical assumptions, research foci and cognitive backgrounds led to different conceptualisations of the core learning processes (see for example Argote and Miron-Spektor, 2011; Huber, 1991), but researchers agree that they involve processes through which knowledge is enhanced (Argyris and Schön, 1978; Easterby-Smith and Lyles, 2003) and changes occur (Huber, 1991) at the level of the overall organisation. Table 2.1 summarises main definitions and conceptualisations of learning in and by organisations in the core literature.

Table 2.1 – Definitions of organisational learning

REFERENCE	DEFINITION	CONCEPTUALISATION
Cangelosi and Dill (1965)	It 'must be viewed as a series of interactions between adaptation at the individual or subgroup level and adaptation at the organisational level'	Product (of different kinds of stress), sporadic and stepwise
Simon (1969)	Growing insights and successful restructurings of organisational problems by individuals reflected in the structural elements and outcomes of the organisation itself	Change in terms of both insights and organisational outcomes
Argyris and Schön (1978)	Process mediated by the collaborative inquiry of its individual members	Focus on individuals as agents
Fiol and Lyles (1985)	'The process of improving actions through better knowledge and understanding'	Process of improvement
Senge (1990)	A process that results in changes of belief, attitude or skill and mainly concerns internalisation and acquisition of knowledge	Process of change, importance of system thinking
Huber (1991)	'an organisation learns if any of its units acquires knowledge that it recognizes as potentially useful to the organisation […] even if not every one of its components learns that something'	Changes in behaviour from individuals to overall organisation
Argote (1999), Argote (2011), Argote and Miron-Spektor (2011)	'A change in the organisation's knowledge that occurs as a function of experience. […] The knowledge the organisation develops can be explicit or tacit', and 'can manifest itself in a variety of ways, including changes in cognitions, routines and behaviours'.	Process that occurs over time, as a cycle including sub-process of creating, retaining and transferring knowledge

The literature on organisational learning is vast and is beyond the scope of this thesis. In the following, only the implications derived from the previous literature on learning from projects at the level of the overall organisation will be considered.

2.2.2 Project-based Learning as a form of Organisational Learning

Much attention has been directed to conceptualise the ability of organisations to learn and then identify the most effective and efficient processes for achieving it (Huber, 1991; Senge, 1990). Learning takes place following knowledge creation and capture (for example through repositories), and the knowledge should be applied and embedded within organisational processes (Liebowitz and Megbolugbe, 2003). In fact, learning foremost is a social process that carries to the augment of knowledge (Bartsch et al., 2013). According to Cook and Brown (1999), a definition of the type of learning requires an essential understanding of the 'generative dance' between the organisational 'knowledge' (which is static and *about* the tangible world) and the organisational 'knowing' (as part of the action of one or more knowers while interacting with other objects and groups). The production of new knowledge and new ways of using knowledge, and then of innovation, lies within a situated interaction with the social and the physical world, where the generative dance takes place.

Among the key environments for learning, firms achieve organisational learning through and from projects (Prencipe and Tell, 2001), defined as a 'subset' of organisational learning (Brady and Davies, 2004). Differing from the systematic learning that take place in functional, high-volume productive processes, it is linked to the so-called 'actuality of projects' (Cicmil et al., 2006), as a process embedded in and continuously re-shaped by local, real-time interactions of people working in project environments. It is about processes and practices and it doesn't concern learning technical knowledge from the project (Williams, 2008).

Learning through and across projects has been recognised by scholars and practitioners as increasingly important to competitive success and to meet a company's strategic and operational objectives (Brady and Davies, 2004; Bresnen et al., 2004). Project-based learning takes place either within the same project (within or intra-project learning) or between one project and another, i.e. between or project-to-project learning (Ayas, 1996; Koskinen, 2012). Along with this line, learning is intended through or from projects (Brady and Davies, 2004).

2.2.3 From Projects to Project-based Organisations

Every project is situated in a wider organisational and historical context (Engwall, 2003). Another dimension of project-based learning investigated in literature is between individual projects and the wider organisation (across projects or project-to-organisation learning). This is defined as a process consisting in the acquisition of knowledge within project ventures, and the codification and transfer of that knowledge to an enduring environment (Prencipe and Tell, 2001). It involves collecting and making newly created project-level knowledge available to the organisation as a whole by sharing, transferring, retaining, and applying it to other projects and across the wider organisation. Previous contributions have mostly focused on single and one-shot learning practices within a single project or between projects, with less emphasis on the generation and diffusion of the knowledge gained at a larger scale, i.e. to their wider organisations (Brady and Davies, 2004).

This level is particularly important in the so-called project-based organisations. This term identifies an organisational form whereby projects are the primary units for coordinating and integrating production, organisation, innovation and competition (Hobday, 2000; Lundin and Söderholm, 1995; Whitley, 2006). The mainstream activities are entirely (or mostly) based on projects, usually for the design of bespoke solutions (Koskinen, 2012) and the production of one-off, unique products to fulfil the requirements of customers (DeFillippi and Arthur, 1998; Gann and Salter, 2000; Hobday, 2000), either internal or external (Turner and Keegan, 1999). A PBO may also sometimes be called project-based firm or PBF (e.g. Lindkvist, 2004; Prencipe and Tell, 2001; Whitley, 2006), or enterprises (e.g. DeFillippi and Arthur, 1998). In general terms, PBOs are entities that organise their activities around numerous individual projects (Grabher, 2002). In the following, this study will generally refer to PBO as a way of organising based on the adoption and carrying out of projects as the primary mechanism for the main functions within a single company (at the level of the organisation as a whole or a single department or business unit).

Project-basing has been widely recognised as an appropriate way of organising for innovation (Hobday, 2000) and for achieving organisational learning through projects (Prencipe and Tell, 2001). The single projects are the locus where knowledge creation takes place thanks to variation, as people try new ways of working. The overall process of learning in project-based organisations requires the subsequent selection, retention in knowledge repositories and reuse of the knowledge created in prior projects to generate new value (Bartsch et al., 2013; Keegan and Turner, 2001). Prior completed projects can offer potentially valuable experiences and lesson learned (Williams,

2008) that can be applied in future projects or even generalised for new business perspectives of the firm (Brady and Davies, 2004). Within the context of project-based organisations and firms operating in project environments (Hobday, 2000), learning within and across projects becomes strategic for the competitive success of the organisation as a whole (Brady and Davies, 2004; Levitt and March, 1988). The learning gained through projects has a key importance in meeting the strategic and operational objectives of these organisations (Middleton, 1967), also for the progress of each individual project.

Finally, a stream of literature (e.g. Leufkens and Noorderhaven, 2011) is studying learning through projects in an inter-organisational setting. As carrying out projects often involves operating in coalitions forming multi-organisational project teams, the involved companies may over time collaborate on multiple projects (Leufkens and Noorderhaven, 2011). Within this setting, the distribution of activities among several companies, their self-interests, the formal contracts linking them together and the bounding of knowledge exchange in the short term are the main factors affecting the ability to work together and learn to collaborate (Leufkens and Noorderhaven, 2011). As this thesis focuses on the organisational learning, i.e. how a single organisation faces the complexity of its projects from an organisational learning perspective, the inter-organisational setting of project-based learning is beyond its scope.

Figure 2.2 summarises the dimensions of organisational learning that have been studied in literature, with a focus on project-based organising.

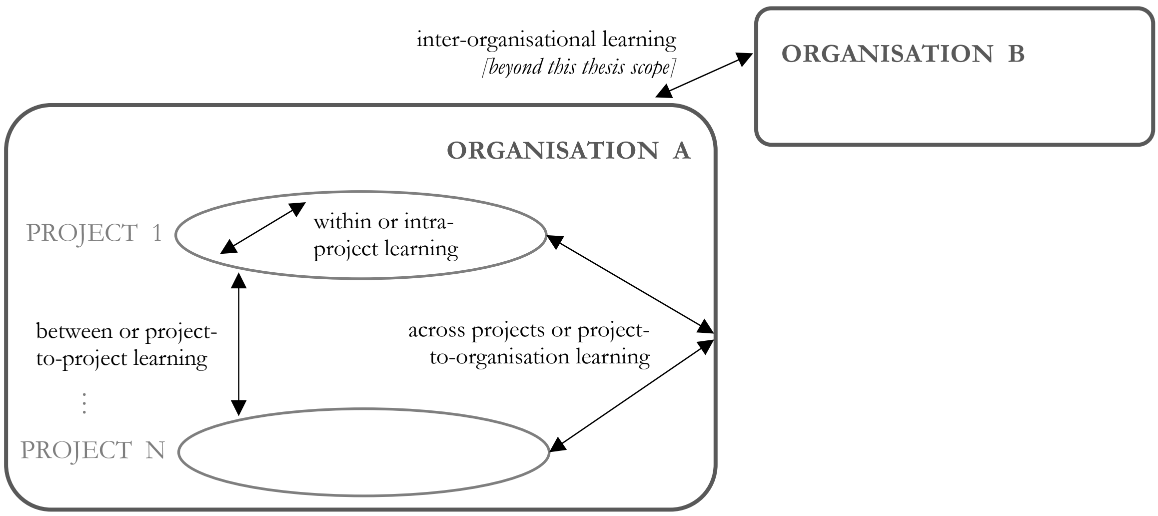


Figure 2.2 – Dimensions of analysis of learning in projects and project-based organisations

Starting from these considerations, the following analysis identifies some key issues for the process of learning within and across projects and integrates the contents explored in the organisational learning literature.

2.3 Key Themes of Organisational Learning in Project-Based Organisations

Organisational learning from projects faces significant challenges due to the uniqueness, the one-off and constrained nature of projects and the distributed knowledge among project teams, which can hinder the codification and transfer of the newly created knowledge to the subsequent projects and the overall organisation (DeFillippi and Arthur, 1998; Edmondson and Nembhard, 2009; Keegan and Turner, 2001; Lundin and Söderholm, 1995; Scarbrough et al., 2004; Prencipe and Tell, 2001). This section draws challenges and implications for project-based learning, integrating the future research directions identified in the more recent literature reviews on organisational learning. Due to the importance of the context-dependency, embeddedness and specificity in understanding the process of organisational learning (Bresnen et al., 2005), the main issues arose on organisational learning from projects are even more significant in the project-based organisations (or project-based firms).

Organisational learning has been emphasized as a key performance driver for firms. This is true also in project-based organisations (Blindenbach-Driessen and van den Ende, 2006; Brady and Davies, 2004; Söderlund, 2004). However, previous research on project-based learning has consistently highlighted the difficulties involved in attempting to capture, share and transfer to the wider organisation the learning and knowledge gained through projects (Middleton, 1967; DeFillippi, 2001; Prencipe and Tell 2001). The temporary nature of project organisations, resulting in a higher pressure towards the end of the project and focus on short-term deliverables, and the fundamental complexity of projects, have been recognised among the key issues that inhibit such learning (Mainga, 2017; Williams, 2008). Further research is needed to investigate the factors that affect the dynamics of knowledge formation over the project lifecycle, including both the 'known' knowledge and the 'knowing' (Ahern et al., 2014, Cook and Brown, 1999). Among these, it is important studying the context in which learning occurs (Argote, 2011) and the factors that affects the dynamics of knowledge formation and sharing (Ahern et al., 2014). Sense (2007) highlights that in the literature embracing sociological aspects of project management, main studies focused on the advantages of learning within the project and from post-project review processes, rather than project environment – e.g. features of complexity.

Along with this line, major features of project-based organisations are: (1) the emphasis on the short-term performance (i.e. tasks completion) and the challenges linked to the compliance with the project constraints; and (2) the dispersed system of practice resulting from the decentralisation of tasks (Bresnen et al., 2005), with the need to identify proper ways to capture, share and transfer knowledge in temporary and project-based organisations, such as the creation of the so-called "knowledge communities" (Lindkvist, 2005). Basing on this, the following sections deepen the analysis of these two issues.

2.3.1 Organisational Learning and Project Constraints

The project process can be defined as a low-volume and high-variety activity that has predefined boundaries and is restricted by a large number of constraints, which principally focus on time, cost and quality (Maylor, 2005). Balancing the competing project constraints for a successful delivery of a project (PMI, 2013a) requires a short-term and practice-based focus.

Learning in projects is affected by the key aspects and nature itself of projects. There is an inherent contradiction between organising to meet short-term objectives through project task and the longer-term relationships required in the nature of the organisational learning processes (Bresnen et al., 2004; Grabher 2002). Specifically, the Scandinavian Project Management School – starting from the seminal works of Lundin and Söderholm (1995) and Packendorff (1995) – defines them as temporary organisations. Because of this intrinsic one-off and non-recurring nature of project activities (Brady and Davies, 2004), any learning from individual projects risks being dissipated and lost to future projects and the same mistakes repeated (Middleton, 1967). When a project is completed, unless the experienced gained is transmitted to subsequent projects, there is often little time or attention paid to identify proper means to collect, store and share information and knowledge created (Brady and Davies, 2004). One of the most common consequences of not reviewing a finished project is that the actions and decisions that caused problems and errors in the past may be repeated in the future (Dooley et al. 2005; Middleton, 1967). While permanent organisations generally adopt mechanisms for learning to take place, in the project-based ones the importance of knowledge formation (i.e. embedding the learning) (Williams, 2008), routinized learning (Hobday, 2000) and systematic repetition (Gann and Salter, 1998, 2000) is overcome by privileging short-task performance (Bresnen et al., 2004).

Organisational learning has been considered a key strategic variable for project management (Ayas, 1996; 1997), to be integrated into core processes (Cavaleri and Fearon, 2000). More recent literature recognises learning as mutually constituted with the management of projects as an organisational practice (Ahern et al., 2014; Winter et al., 2006). Moreover, a systemic thinking and understanding is the necessary base to gain learning from projects, allowing the proper lessons to be learned (Sense, 2007; Williams, 2008). The systematic enactment of learning processes includes institutionalised and procedural mechanisms that allow organisations to systematically collect, reflect, disseminate and use information. The codification of knowledge implies a loss of part of it in the transformation process, but codification itself can stimulate learning. It is important that the static and explicit 'known' knowledge (e.g. documents, design plans, etc.) is studied with the dynamic and 'experiential' knowledge or 'knowing' (e.g. know-how), overcoming the expectation of traditional planning approach for a little knowledge formation and learning during the execution of the project plans (Ahern et al., 2014). Learning should be facilitated by business processes for both short-term achievements of project outcomes and long-term project skills capability (Ayas, 1997; Sense, 2007). Along with this line, a better understanding of factors enabling learning processes within projects is required. This should be focused not only in relation to the single projects goals and the professional development of the team members (Sense, 2007).

Project processes are generally temporary and unique (Lundin and Söderholm, 1995; Packendorff, 1995), with non-routine features that can hinder learning (Williams, 2008). Key characteristics of projects include high levels of customisation according to customer demands (or because previous solutions are obsolete), the discontinuity at both temporal and organisational level), complexity, interdependence and uncertainty (Brady et al., 2002). For these reasons, it is not always possible to rely on past experience to solve current problems. At the same time, there is a "misguided belief" that all projects are completely different, further inhibiting learning (Cooper et al., 2002).

Furthermore, Williams (2008) recognises that projects cut across organisational functions and require creating the knowledge within the context of application and specifically as transdisciplinary, beyond the traditional functional structures. A possible solution for obtaining advantages in this sense is the cross-functional teams, which is used to incorporate the possession of a valuable knowledge that integrates all necessary perspectives into the learning process of the overall organisation (Edmondson and Nembhard, 2009).

2.3.2 Knowledge Communities in Project-Based Organisations

A project is defined as "a temporary endeavour undertaken to create a unique product, service, or result" where the adjective 'temporary' "refers to the project's engagement and its longevity" (PMI, 2013a: 2). As projects are often one-off, self-contained and temporary and complex tasks, they often require dedicated modes of organisation and management practices, beyond routine organisational processes (Grabher, 2002; Tonchia and Nonino, 2013). The circumstances of a project-based organisation such as the emphasis on short-term performance result in a logic of action that poses important challenges for the embedding of knowledge associated with new project management practice (Bresnen et al., 2004). For example, a key issue is the paradox of planning in advance complex projects since they can't be fully specified. A valuable resolution involves the project team in overcoming the missing knowledge through problem-solving learning

(Ahern et al., 2014). Moreover, the progressive and iterative elaboration of the project management plan involves continuously improving and detailing the adopted practices throughout the project's life cycle, as more detailed and specific information and more accurate estimates become available (PMI, 2013a). In an organisational setting where the management is project-based, the need to review and to learn from each project – and from one project to the next – is of vital importance to develop a capability of managing projects successfully (Williams, 2008).

The nature of knowledge and learning at organisational level, identified as socially embedded, situated and continuously re-shaped by local, real-time interactions of people working in project environments in the so-called 'actuality of projects' (Cicmil et al., 2006), results in a subsequent difficulty in sharing knowledge and learning form one context to the other (Brown and Duguid, 1991; Orlikowski, 2002). This represents a major challenge in a project-based organisation that organises the core design and production processes around projects. The created knowledge appears to be highly specific within the particular, multi-professional project team, resulting into the development of a decentralised project management practice and the co-existence of networks of practice (Bresnen et al., 2004; Brown and Duguid, 1991; Lindkvist, 2005).

Previous literature provides both theoretical and empirical evidence that the process of organisational learning in project-based organisations, and specifically the re-embedding of newly created knowledge into a shared project management practice (Bresnen et al., 2004) is enhanced by specific context conditions. Major contextual factors can be distinguished in technical, managerial and social. Some authors enlighten the key role of the social context conditions in facilitating different organisation-level learning outcomes (Bakker, 2010; Bartsch et al., 2013).

A major aspect is the role of the communities of practice (Brown and Duguid, 1991; Ruuska and Vartiainen, 2005; Wenger and Snyder, 2000) that allow promoting a unified understanding of working and learning, and teams' social capital (Bartsch et al., 2013). Specifically, we refer to the communities of practice in project-based organisations with the term "knowledge community", as defined by Lindkvist (2005). The author proposes this epistemology to present and characterise the communities of practice within the context of projects and temporary organisations. Specifically, the concept refers to a context of practice-based learning, where decentralised sub-units develop shared, experience-based knowledge by working close together.

Table 2.2 summarises the main concepts of organisational learning in project-based organisations, as derived from the literature review of this Chapter.

Table 2.2 – Issues of organisational learning in project-based organisations

ISSUES OF ORGANISATIONAL LEARNING IN PBOS		REFERENCES
Project constraints	Short-term objectives vs. longer-term relationships Tight schedules, high quality requirements, budget One-off and non-recurring nature of project activities Less opportunities for routinized learning Build-up of cross-functional teams Capacity and process optimisation	Ahern et al., 2014; Ayas, 1997; Brady and Davies, 2004; Bresnen et al., 2004; Grabher 2002; Lundin and Söderholm, 1995; Packendorff, 1995; Sense, 2007
Knowledge communities	Embedding of knowledge Decentralised project management practice Co-existence of networks of practice Social context conditions (facilitating "working together") Experience-based knowledge	Bartsch et al., 2013; Bresnen et al., 2004; Brown and Duguid, 1991; Grabher, 2002; Orlikowski, 2002; Lindkvist, 2005; Tonchia and Nonino, 2013

Chapter 3.
Research Methodology

3.1 Problem Formulation and Research Questions

The complexity of most projects is rapidly increasing (Williams, 1999). Projects are becoming more complex, with components more independent, and adapting to more volatile environments (Augustine et al., 2005). This implies a difficulty to coordinate (Davies and Mackenzie, 2014) and control all aspects of the project (Gransberg et al., 2013). Dealing with the interdependency, uncertainty and change of contemporary projects (Davies and Mackenzie, 2014) and the dynamic environments in which they operate poses new challenges (Cooke-Davies et al., 2007) and requires a different approach (Williams, 2002; Bosch-Rekveldt et al., 2011). Many studies have recognised that traditional project management methods towards the "Tayloristic one best-way approach" as a reference model to apply to any type of project or industry, and conventional linear systems are not more sufficient to properly address the increasing complexity of projects (Costantino et al., 2015; Williams, 1999; Winter et al., 2006). The understanding of project complexity should be then progressively developed (Chapman, 2016) in order to better configure the front-end phase (Bosch-Rekveldt et al., 2011) and then achieving – and improving – duration (schedule), quality and cost (budget) goals for project success (Dawidson et al., 2004). Moreover, an objective measure of complexity could provide continuous feedback to help control the process of project development (Baccarini, 1996; Xia and Chan, 2012).

This is true especially in multi-projects environments, e.g. the project-based organisations, defined as a type of organising whereby projects are the primary units for coordinating and integrating production, organisation, innovation and competition (Hobday, 2000; Lundin and Söderholm, 1995; Whitley, 2006). The mainstream activities are entirely (or mostly) based on projects, usually for the design of bespoke solutions (Koskinen, 2012) and the production of one-off, unique products to fulfil the requirements of customers (DeFillippi and Arthur, 1998; Gann and Salter, 2000; Hobday, 2000). These organisations face specific challenges when capturing, sharing and embedding new knowledge and learning from projects at the overall organisation level (Brady and Davies, 2000; Bresnen et al., 2004; Keegan and Turner, 2001; Lundin & Söderholm, 1995). This is mainly due to the decentralised organising of the teams, the interfaces between the temporary and permanent organisation (Stjerne and Svejenova, 2016) and the ways of working constrained by tight schedules and optimisation towards the achievement of the single project goals, resulting in distributed knowledge and working practices (Bresnen et al., 2004; Lindkvist 2004; Orlikowski 2002). A consideration of the contextual conditions (e.g. level of complexity of the projects) for organisational learning and the processes of emergence is therefore required (Maguire et al., 2006; Mitleton-Kelly and Ramalingam, 2011). Moreover, teams are defined as the fundamental unit of learning and organisational effectiveness (Leonard-Barton, 1995; Nonaka and Takeuchi, 1995; Senge, 1990).

Despite the increasing interest towards project complexity, there is still a lack of common understanding of the concept (Bosch-Rekveldt et al., 2011; Cooke-Davies et al., 2007; Maylor et al., 2008; Geraldi et al., 2011; Vidal et al., 2011), mainly due to the diverse theoretical lenses and influencing factors considered in the analysis. Previous studies focused on identifying concepts, dimensions, types, elements, measures, practices to cope with. Despite the wide scope of the literature, little research focused on the elements of complexity in a multi-project environment, e.g. project-based organisations, and considered the hierarchical aspects and the emerging dynamics, e.g. learning. A review of the literature on organisational learning in project environments, i.e. learning at the teams and the overall organisation level, revealed the key issues of project constraints and the need to build knowledge communities. This is mainly due to the temporary organising of project teams and distributed knowledge and project management practices among them, with difficulties to share and transfer the lessons learned to the overall organisation.

This thesis aims to investigate how organisations are facing the complexity of their projects based on reflections and perspectives of the members with key roles in the project management process of a project-based organisation. It addresses the recent call for new perspectives towards project management in line with the current "rethinking project management" stream of study (Biedenbach and Müller, 2011; Svejvig and Andersen, 2015).

Therefore, the research questions were formulated as follows:

> *1) How do organisations understand and face project management complexity within their projects from an organisational learning perspective?*
>
> *2) How can organisations face project management complexity across their projects from an organisational learning perspective?*

The final goal is to gain a deeper insight into project complexity as a feature of projects influencing learning processes of project teams and project-based organisations. The thesis is particularly concerned with the practical aspects of learning where project organising supports the main business of companies, viewed from a project management perspective.

This premise is an important consideration in selecting the research methodology and methods suitable to the purposes of the study.

3.2 Research Philosophy and Approach

The philosophical orientation represents the foundation of the research process and directs the selection of the research methodology. This study adopts an interpretivist position as we consider the phenomena under investigation as a result of the different ways the individuals comprehend reality, according to their mental model, perceptions and subsequent behaviour (Jaafari, 2003). This approach addresses the definition of projects as complex social settings with socially constructed conceptions (Cicmil et al., 2006; Lundin and Söderholm, 1995).

The interpretivist paradigm is recurring in organisational learning literature (Mitleton-Kelly and Ramalingam, 2011) and it is the most popular throughout the years for project management researchers (Biedenbach and Müller, 2011). Moreover, Easterby-Smith et al. (2000) observe that the European scholars place more emphasis on interpretative methods to investigate organisational learning.

The methodological approach underpins the choice of the research design and represents the base for identifying: what data will be required to answer the research question, how will the data be analysed, and whether the research aims to gain a better understanding of the phenomena rather than to describe it (Easterby-Smith et al., 2000). In line with the interpretivist philosophy underpinning this study, the approach adopted in the current research combines deductive, theory-driven and inductive, data-driven methods.

Although the research question has been formulated from a systematic literature review, the wider frame of reference that has been identified does not play a role of rigid theory or hypothesis to be tested. Deductive methods are used to identify core theoretical constructs relating to project complexity in the wider project management and organisation literature. Along with this line, prior assumptions and constructs provided a foundation (Glaser and Strauss, 1967) and helped to make sense of the emerging findings in the following data collection and analysis.

The phase of data collection involved inductive methods, driven by data, thus surfacing new concepts and generating new insights (Gioia et al., 2012) for the categories derived from the literature review. During data analysis, a regular iteration between empirical data and investigation frameworks guided the study direction. Established theories are used to code findings, informing second order codes and deriving models from the data. Finally, the contributions and limitations of this study are drawn from comparison with existing theory by using deductive reasoning.

3.3 Research Design

Aiming for sense-making and increasing understanding of phenomena under investigation, this study applies a qualitative method (Biedenbach and Müller, 2011). The carefully established rationale guiding the selection of the research design follows the points raised by Yin (2013) for qualitative research methods. Specifically, the empirical research focuses on a "how"-type question and the focus of the research is a contemporary, complex phenomenon, i.e. emerging features and organisational learning processes (Cook and Brown, 1999). As highlighted in the previous paragraph, the research problem addresses a process not yet deeply investigated, and a holistic study that includes contextual conditions is required (Yin, 2013), as the learning process takes place within and across projects. The research is qualified as being exploratory in approach, as it aims to: 1) clarify and define the nature of learning in complex projects, 2) add new concepts and insights to the understanding of the dynamics and emergent properties of complexity in project environments (Gioia et al., 2012) and 3) give a better understanding of the investigated concept as well as identify important factors that could be tested in future studies (Yin, 2013).

Moreover, recent project management literature (e.g. Lessard et al., 2014) requires taking into account the institutions within which a project is embedded and interacts, extending the contingency-based approaches (Shenhar, 2001). A new approach to projects requires then to study them as a nested, or embedded phenomenon, as every project is situated in a wider organisational and historical context (Engwall, 2003). In the case of project-based organisations, the existing organisational practices and broader networks of relations encompass the organisational and institutional context within which projects are embedded (Bresnen et al., 2004; Lindkvist, 2004). Adding to this point, the context in which learning takes place has a nested nature, i.e. learning within single projects and across projects is nested, or embedded, within the broader organisation level (Scarbrough et al., 2004).

Following these assumptions, we employed an embedded cases study design. A case study design allows an empirical inquiry that investigates a phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly defined as in the case of the learning process in project-based organisations (Yin, 2013). Moreover, previous studies (e.g. Aritua et al., 2009) show that concepts from complexity theory provide a fruitful understanding of multi-project management and should, therefore, form the basis for a case study analysis. A case study is a history of a past or current phenomenon, drawn from multiple sources of evidence (Yin, 2013). It can include data from direct observation and systematic interviewing as well as from public and private archives. Sources are chosen basing on the fact that any contextual element relevant to the stream of events describing the phenomenon is a potential datum in the case study (Stone, 1978). Of the four possible different types of case study design, we adopted a single embedded case study, as it enables an in-depth understanding of the phenomenon with the control of a number of different external factors that might affect the managerial actions (Turkulainen et al., 2015). Through this research design, different levels or sources of data are collected in order to engage in a rich analysis (Yin, 2013).

This case comprises an in-depth study of the dimensions of project complexity and learning in one firm, embedded within which are multiple levels of analysis. In fact, including multiple units in a study makes the findings and interpretations more compelling, allowing to corroborate, qualify, or extend the analyses within, between and across all the subunits and the larger nested case. Considerable attention has been paid to the broader organisational setting, avoiding the potential hazard of focusing only on the subunit without returning to the larger unit of analysis (Yin, 2013). The embedded design provided a control for factors such as organisational (and environmental) context-dependency and the observed outcomes (i.e. learning processes at organisational level).

A well-designed protocol is particularly important when carrying out a case study (McCutcheon and Meredith, 1993), aiming to enhance the reliability and validity of the case research (Yin, 2013). Following these references, a research protocol was built. The protocol includes the methods to be employed and tasks to be performed in the phases of design (stating the objectives, the boundaries and the case selection), the definition of the investigation frameworks, data collection, data analysis. These are further detailed in the following sections.

3.3.1 Unit of Analysis

Miles et al. (1994) define a case and consequently the unit of analysis as "a phenomenon of some sort occurring in a bounded context" (p. 25). The identification and description of the unit of analysis and in general of the boundaries of the study highly depends on adopted research methods. Moreover, it helps in maintaining consistency between the phenomenon observed and its context.

This study involves more than one unit of analysis that is bound for definition and context. Specifically, in an embedded case study, the main case study is a broader or larger unit and the multiple case studies (and the cross-case synthesis) serve as embedded units. Following recommendations from literature (Miles et al., 1994), the unit and sub-units of analysis have been identified as follows: 1) the main unit is the project-based organisation, 2) the sub-units are the ongoing (not completed) projects. The inclusion of multiple cases as sub-units allows getting a broad view of the project complexity and the project-based learning at the organisational level both within and across multiple projects.

3.3.2 Quality of the Research

This section outlines the validity issues taken into account throughout the research and the criteria considered and applied for ensuring its quality. This study was conducted having clearly in mind that any research faces threats to validity and needs to continue addressing design challenges, especially in a case study design (Yin, 2013). Whilst the insights generated by interpretive qualitative research are substantial and revelatory, such studies have been often criticised for lacking scholarly rigour (Gioia et al., 2012) and mainly addressing the particular, whereas they fail in addressing the general (Smyth and Morris, 2007).

Commonly used criteria for judging the quality of an empirical research in social sciences are: construct validity, external validity, internal validity and reliability (McCutcheon and Meredith, 1993; Rowley, 2002; Yin, 2013). The definition of each test, the tactics suggested in literature and the ones applied in this study to ensure the quality of the research are shown in Table 3.1. Considerable attention has been paid to rigour throughout the study, aiming to lead to plausible, trustworthy and defensible research (Gioia et al., 2012).

Table 3.1 – Criteria and tactics for the quality of the study

TEST	DEFINITION	TACTICS IN THIS STUDY
Construct validity	Identifying correct operational measures for the defined constructs	• Using multiple sources of evidence during the data collection phase • Interviewing multiple informants, whose answers complemented to each other • Revision of the draft case study reports by at least two of the key informants involved throughout the research • Establishing chains of evidence while collecting the data
External validity	Extend to which findings are generalizable beyond the immediate study (analytical, theoretical and not statistical generalisation for case studies)	• Replication logic for each sub-unit (project) • Identifying commonalities and differences across projects
Internal validity	Strength and confidence of the cause-and-effect relationships, in part determined by showing the absence of spurious relationships and the rejection of rival hypotheses	• Triangulation of multiple data sources • Pattern-matching and explanation-building during the data analysis phase
Reliability	Minimise the errors and bias in the study, demonstrating that the operations of the study can be repeated, with the same results	• Using a case study protocol to guide field research and analysis • Developing a case study database containing documents, presentations, field notes, recordings, transcripts • Reflexivity at every stage of the research, with a clear awareness of the possible influence of the researcher's preconceptions, beliefs, values, assumptions and position in the study

3.4 CASE SELECTION: FINCANTIERI

This case study develops an in-depth analysis to investigate how to cope with complexity in projects and in project management at one firm level. Embedded within this are multiple accounts of organisational learning at the single and cross-projects levels.

The chosen case is Fincantieri, one of the world's largest and most diversified groups in the shipbuilding industry. The organisation is both an exemplary case containing extreme circumstances and a revelatory case (McCutcheon and Meredith, 1993), further sustaining the choice of the single case study design. During over 230 years of history, Fincantieri has built more than 7.000 vessels, becoming the leading Western shipbuilder for diversification, innovative capability and geographical distribution. The Group includes 21 shipyards distributed in 4 continents and employs almost 19.200 personnel (more than 7.900 only in Italy). Including the satellite industrial firms that collaborate with the Group, the number of employees extends to more than 80.000 people. The high level of synergies and flexibility of the subsidiary companies and the shipyards allows adopting a network configuration that optimises the results of the overall Group in terms of efficiency and profitability.

Fincantieri is a cutting-edge and active player in all the in all high-tech and highest added-value sectors of the shipbuilding industry. These include naval vessels, ranging from high-complexity, special vessels for leisure (cruise ships) and ferries to mega yachts; offshore vessels (especially oil and gas); ship repairs and conversions; systems and components production; and after-sales services. The company has among its clients the major cruise operators, the Italian and the U.S. Navy, in addition to several foreign navies, and it is a partner of some of the main European defence companies within supranational programmes. The headquarters are based in Trieste (Italy), one of the major Mediterranean port cities.

FINCANTIERI

Figure 3.1 – Company logo

Specifically, the company is the global leader in the construction of cruise ships. It was among the first naval builders to seize the opportunity for the development of cruise tourism in the 1990s and entered the segment by exploiting the experience gained in previous decades as a transatlantic builder. During the years it has developed a diversified portfolio of cruise vessels with a size ranging from 10.000 to over 140.000 gross tons of size and a length of between 110 and 330 meters. Aiming to deliver ships fully tailored to the needs of all types of customers and touristic tours, four sub-segments have been defined: Luxury/Niche, Upper Premium, Premium, Contemporary. These are constructed in four Italian shipyards – based in Monfalcone, Marghera, Sestri Ponente and Ancona– and two foreign ones (owned by Vard, one of the subsidiary companies) that work in synergy as one under the Merchant Ship business unit. The cruise ships sector accounts for almost half of Fincantieri revenues. In the following of this dissertation, Fincantieri will be mentioned referring the only Merchant Ship Business Unit. Nowadays Fincantieri consolidated its decades of experience in the technology, design and engineering of the overall ship's system in an integrated system model that oversees all stages of the cruise ships production, including design, supplier selection, construction, commissioning, testing and delivery. Aiming to constantly maintain a flexible approach and meet – and even anticipate – the demand of the modern cruise industry, its configuration is a project-based company, where the project management is one of the key processes and has a dedicated unit.

The subsequent chapter of this thesis (Chapter 4) provides a detailed description of the empirical findings in Fincantieri and the context of analysis. The purpose of this section is to describe the rationale behind the selection of Fincantieri as a case study for this research, i.e. the empirical, theoretical and methodological reasons.

Empirically, Fincantieri is one of the largest and most diversified shipbuilders worldwide and is renowned for being the world leader in the construction of cruise ships. Throughout its historical evolution, the company has been able to implement new strategies and adapt its organisational model in order to retain long-term competitiveness and then successfully survive and growth, also during the worldwide crisis that impacted both the shipping and the shipbuilding industry. It managed to maintain a strong position in delivering highly specialised and qualitatively outstanding vessels, relying on the strong expertise in the development of high-tech solutions for different segments and the competence in the project management process. Overall, Fincantieri is leading all the knowledge domains judged as key for the organisational performance, i.e. knowledge about market conditions, about products and technologies, and project management (Bartsch et al., 2013). Moreover, the organisation shows a positive attitude towards further professionalisation of project management unit and fostering mechanisms and approaches for learning at the organisational level in front of the increasing complexity of its projects.

The selection was made also for theoretical reasons. As discussed in Chapter 2, the process of organisational learning is viewed as embedded, as projects are situated within complex and institutional settings (Cicmil and Marshall, 2005). The richness of the embedded perspective is increased by the company and the industry (shipbuilding) as being project-based. Moreover, shipbuilding is one of the most complex environments for decision making (Romano et al., 2010) and it shows a high level of technical, organisational and environmental complexity (Bosch-Rekveldt et al., 2011).

Firstly, the cruise ships are characterised by a high degree of diversity and richness, especially in the layout of the part dedicated to the hospitality and entertainment services. Each ship is complex, custom-made and has to be designed to the unique requirements of the customer (Davies and Brady, 2000; Leufkens and Noorderhaven, 2011; Pero et al., 2015), i.e. the shipowner. A cruise vessel can be defined as a system, i.e. a "complex collection of interactive elements and subsystems within a single product, jointly performing a wide range of independent functions to meet a specific operational mission or need" (Shenhar and Dvir, 1996). Indeed, it includes several subsystems with different functions (e.g. engine and conditioning) with the aim of offering unique and dedicated cruise experiences to the tourists. The complexity of the products is reflected in the design and construction process, which involves numerous activities that have to be effectively coordinated and integrated by the project management teams. The design process has to take into account also the long-term project to deliver the completed vessel and the features of the shipyard in charge of constructing the vessel. High coordination is required when

Secondly, Fincantieri (with the Merchant Ship business unit and its shipyards) acts as both prime contractor and system integrator (Leufkens and Noorderhaven, 2011; Sauerhoff, 2004). For each vessel project, it has to coordinate a wide network of heterogeneous suppliers and sub-contractors involved in the design and production activities and to integrate the internally and externally developed components (Davies, 2004). Moreover, the customer is deeply involved in possible modifies to the ship design for the duration of product development and project implementation process (Davies and Brady, 2000). Dealing with a variety of (and often conflicting) interests of external stakeholders, the company has been able to develop formal contractual agreements, shared goals, planning, and persuasion to transform the interdependencies between them in a close cooperation, in the attempt of addressing the network-wide goals that the project aims for (Brady and Davies, 2014). In Fincantieri, project teams work between temporary project settings and the more enduring activities of the firm. They are ultimately responsible for delivering the finished vessel on time and according to customer specifications (Ahola et al., 2008). As is typical in complex operations, teams work in complex and multiple settings, where the overall firm, the single project and the stakeholder demands collide and sometimes conflict, leading to dynamic processes that often require non-linear procedures (Antoniadis et al., 2011).

Finally, methodological reasons were also considered in the selection of the case. In accordance with the qualitative research techniques used, a good access to the selected firm was necessary, in terms of both location and availability of information. Firstly, headquarters of Fincantieri is based in Trieste, then the physical proximity enabled many face-to-face interactions in the company throughout the period of data collection and analysis. As this study builds on perceptions and experiences of people working in the shipbuilding industry, data was collected in the natural setting (Lee, 1999). Secondly, the researcher has benefited from the availability of two senior sponsors, who arranged access to the organisation and involved other individuals to participate in the data collection. This support greatly improved the access and quality of information provided during data collection (Voss et al., 2002).

For the above reasons, this setting has offered extraordinary opportunities for studying how organisations face the complexity in projects and in project management from an organisational learning perspective. Specific boundaries have been considered.

The scope of the case has been purposefully limited to a specific sector, i.e. the building of cruise ships. The aim of establishing this boundary is to restrict the technological, geographical and commercial variables that could confound accounts of the typology of projects (Shenhar and Dvir, 1996) and the organisational learning processes that take place within and cross-project teams (Prencipe and Tell, 2001).

A further boundary in this study relates to the temporal setting. By taking into consideration the limitations in terms of resources and time for the study (Patton, 2002), but also the will to investigate differences in complexity dimensions and resulting learning processes, the sub-units (i.e. the projects) were selected through deliberate "theoretical sampling" (Glaser and Strauss, 1967). During the study, the project teams in Fincantieri (Merchant Ship business unit) were employed in a total of 7 major projects, aiming to deliver 7 out of the total vessels included in Merchant Ship Business Unit portfolio (at the time of the study). The sample can be then considered representative of the overall project management process, as on average the number of constructions delivered in a year ranges between 10 and 12, with between 6 and 7 ships in different phases of the production process, due to the limited capacity of the shipyards (and specifically of their dry dock). Moreover, the population of 7 projects shows complex multivariate conditions (Yin, 2013), with a variance on the criteria (Eisenhardt, 1989; Shenhar and Dvir, 1996): size of the ship (measured in gross tons tonnage), type of ship (in terms of technological newness), shipyard (production site), delivery date (therefore corresponding to different timings in the project development), the customer (highlighting the distinctive features).

Table 3.2 shows the projects (with fancy names for the cruise ships and the shipyards) and their features. These projects provided the immediate social and temporal context for the learning within the project and the level of project complexity. Commonalities and differences across the varied projects helped to outline the patterns upon which to develop theoretical insights (McCutcheon and Meredith, 1993). Therefore, the following phase of data analysis included the two steps of within-case and cross-case analysis was performed (Eisenhardt, 1989; Voss et al., 2002), as further explained in Paragraph 3.8. The results of these phases, with a deepen description and analysis of the seven projects, are reported in Paragraphs 4.4 and 4.5.

Table 3.2 – Overview of the projects selected in the case study

PROJECT				SHIP		CUSTOMER
N.	**Name**	**Shipyard**	**Delivery**	**Size**	**Type**	**Distinctive features**
1	Music cruise ship	Western	Feb 2020	110 k gross tons	Prototype	New client, new entrant in cruise ship market
2	Skyline cruise ship	Daisy	Mar 2018	134 k gross tons	2nd Sister	Historical client, long-term relationship, among key players in the market
3	Northern cruise ship	Daisy	Jun 2022	140 k gross tons	Prototype	Among the most innovative brands
4	Panoramic cruise ship	Eagle	Nov 2017	152 k gross tons	Prototype	New client, among key players in the market
5	Queen cruise ship	Eagle	Oct 2019	145 k gross tons	4th Sister	Historical client, long-term relationship and contract
6	Inspiration cruise ship	Western	Mar 2017	41 k gross tons	Prototype	Brand focuses on luxury and innovative design
7	Eastern cruise ship	Eagle	Mar 2019	136 k gross tons	1st Sister, brand change	New market

3.5 INVESTIGATION FRAMEWORK

Among the measures adopted to ensure the validity and reliability of case research data (Yin, 2013), the design of the research protocol has included the development of an investigation framework. Due to the exploratory nature of the case study design, the conceptual framework allowed to collect and then analyse data by reflecting the emerging themes in categories. Each category included in the framework has been defined from the literature (Chapter 2 and 3) with the aim of comparing the emerging findings in the light of the relevant issues and then achieving a description of the case study that could be corroborated from multiple sources of evidence.

Particular attention has been paid to develop an investigation framework guiding the definition of the guideline to be used in the data collection, the level of detail and the check that all topics have been covered. Basing on these assumptions, two investigation frameworks have been developed according to two main perspectives:

- the first framework underlines the dimensions of project complexity (at the single project and multi-projects level)
- the second framework describes the main dimensions of the learning process (at the team and organisational level)

3.6.1 Investigating the complexity at single- and multi-projects level

The first part of the framework focuses on the variables that allow to characterise and then assess the complexity of a project. The key variables used in this study are identified among the definitions and the dimensions of complexity, as outlined in Paragraph 1.3.1 and 1.3.4, and in particular in the main sources cited in literature (i.e. Baccarini, 1996; Bakhshi et al, 2016; Brady and Davies, 2014; Cicmil and Marshall, 2005; Geraldi et al., 2011; Giezen, 2012; Maylor et al., 2008; Maylor and Turner, 2017; Shenhar, 2001; Williams, 1999). Table 3.3 on the following page shows the dimensions of complexity considered, their definition and the main references (and terms adopted).

Table 3.3 – Investigation framework for the dimensions of project complexity

DIMENSIONS	DEFINITION	DIMENSIONS FROM LITERATURE	REFERENCES: Baccarini (1996)	Bakhshi et al (2016)	Brady and Davies (2014)	Cicmil and Marshall (2005)	Geraldi et al. (2011)	Giezen (2012)	Maylor et al. (2008)	Maylor and Turner (2017)	Shenhar (2001)	Williams (1999)
Diversity	Size, number, heterogeneity and variety of the elements and subunits of the project, including hierarchies	Differentiation	•					•				
		Diversity		•		•						
		Size		•								
		Number of …					•	•		•		
		Hierarchy			•				•			
		Scope									•	
		Variety										•
		Structural complexity					•			•		
Interdependency	Degree and emergence of interactions and connections among the elements and subunits of the project	Interdependency	•				•			•		•
		Connectivity		•								
		Interactions				•						
		Belonging		•								
		Structural (relationships) complexity			•				•			•
Dynamicity	Pace, rate of delivery and change of the project; it includes the temporal aspects (speed)	Pace				•	•					
		Dynamics			•		•					
		Instability										•
		Changes							•			
Uncertainty	Linked to the unknowns, variables to predict and manageability of the project and the planning in terms of novelty, experience, and availability of information	Emergence		•								
		Ambiguity				•						
		Uncertainty					•	•				•
		Unpredictability / Future state unknown			•	•		•				
		Structural (subsystems) uncertainty	•									
		Technological (novelty) uncertainty	•						•	•	•	

We find these definitions suitable for the analysis as they: 1) build on previous contributions in project complexity literature, 2) are theoretically grounded on the key concepts from complexity science, 3) consider both the theoretical and practical perspective. The analysis of the single projects and the multi-projects complexity along with these categories allows to "better appreciate or interpret 'how' a project is complex rather than whether a project is simply complex or not" (Kiridena and Sense, 2016: 64). The same dimensions were analysed at both single- and multi-project level as the principles of complexity are scale-invariant (Mitleton-Kelly and Ramalingam, 2011).

3.6.2 Investigating the project-based learning

The second framework employed in the analysis builds on the key themes in Chapter 2 on organisational learning in projects environments and the processes identified by Prencipe and Tell (2001) and Brady and Davies (2004) in their frameworks. In fact, they describe the learning mechanisms within project environments on micro-level and focusing on knowledge development and codification mechanisms. The focus on these processes has been judged as suitable for the investigation within this thesis, as it aims to integrate knowledge and knowing (Cook and Brown, 1999), emergence and contextual settings. Moreover, the selected projects are all ongoing, and the boundaries of the study don't enable to investigate the process of knowledge transfer, in terms of project-to-project and project-to-organisation. The main issues investigated in this analysis are summarised and defined in Table 3.4.

Table 3.4 – Investigation framework for the dimensions of project-based learning

ORGANISATIONAL LEARNING			**REFERENCES**
Processes	**Experience accumulation**	Experience-based learning, e.g. deriving form learning-by-doing and learning-by-using	Prencipe and Tell, 2001; Brady and Davies, 2004
	Knowledge acquisition	Process of extracting, structuring and organising knowledge from one or more sources, e.g. through imitation or replication	Prencipe and Tell, 2001; Brady and Davies, 2004
	Knowledge codification	Cognitive process that implies deliberation and creation of agreed upon representation through, for example, codified manuals and procedures	Prencipe and Tell, 2001; Brady and Davies, 2004
Project constraints		Short-term objectives vs. longer-term relationships Tight schedules, high quality requirements, budget One-off and non-recurring nature of project activities Less opportunities for routinized learning Build-up of cross-functional teams Capacity and process optimisation	Ahern et al., 2014; Ayas, 1997; Brady and Davies, 2004; Bresnen et al., 2004; Grabher 2002; Lundin and Söderholm, 1995; Packendorff, 1995; Sense, 2007
Knowledge communities		Embedding of knowledge Decentralised project management practice Co-existence of networks of practice Social context conditions (facilitating "working together") Experience-based knowledge	Bartsch et al., 2013; Bresnen et al., 2004; Brown and Duguid, 1991; Grabher, 2002; Orlikowski, 2002; Lindkvist, 2005; Tonchia and Nonino, 2013

Specifically, these themes are investigated within project management, as it is one of the key knowledge domains for the organisational performance, especially in project-based organisations (Bartsch et al., 2013). Moreover, we follow the emerging research field that conceptualise project management as an organisational practice, where organisational learning becomes mutually constituted with the management of the project as a practice (Ahern et al., 2014; Winter et al., 2006). Finally, the same processes were investigated at both within and across team levels (in the multi-projects environment), as the emerging patterns of complex systems can be observed at different scales, from groups to the overall organisation (Mitleton-Kelly and Ramalingam, 2011).

3.7 DATA COLLECTION

The study involved the collection of information from multiple sources. This strategy enabled triangulation (and then developing convergent evidence) of extensive and detailed data and exploitation of the richness and depth of the case study design (Yin, 2013). The data collection covered a period of more than one year, therefore both retrospective and contemporaneous data sources are used. The employed sources of evidence were interviews, field notes from meetings, qualitative questionnaires, documents and archives, company presentations.

An exploratory field research was conducted prior to the systematic conduction of interviews. This phase consisted of the collection of publicly available information about the firm (e.g. press releases and company website) and the attendance to three meetings with senior members and experts of cruise ships projects. The people involved were the manager of the project managers, president and one of the senior managers of the financial planning and control function, two of the project managers (with a long-term experience in Fincantieri). These senior members were firstly contacted as they confirmed their availability, commitment and interest towards the research topic, following the advice by Voss et al. (2002) to involve "someone senior enough to be able to open doors where necessary, to know who best to interview to gather the data required and to provide senior support for the research being conducted" (Voss et al., 2002: 206). Following a dialogue about the research aims and the possible opportunities to deepen the study within the company, the main topics discussed and explained in the preliminary meetings were: an overview of the company (history and profile), an overview of the shipbuilding industry (focusing on the features mainly affecting the company strategy and positioning), Merchant Ship Business Unit organisation (focusing on the multi-projects complexity and the planning and control model), an overview of project management process and practices, project management team (roles and responsibilities), an overview of variables to consider in the investigation of the dimensions of complexity in cruise ships projects. Data from these sources provided a valuable background to learn more about the empirical setting and prepare the following interaction with the informants (Collins, 2004; Collins and Evans, 2008). Moreover, this involvement allowed the researcher to acquire a sufficient expertise on shipbuilding projects – without necessarily being able to practice – in order to study people, subject matter, and their context in meaningful ways (Collins, 2004).

Following this preliminary phase, other five follow-up meetings with the senior roles took place throughout the whole period of data collection and analysis. Main topics addressed were: project management process and practices, main challenges in the management of projects, organisational configurations and changes, dimensions and types of complexity in cruise ships projects, project constraints and performance, mechanisms of cross-projects learning. This process of interaction provided an opportunity to gather further insights, validate the findings and obtain agreement on the accuracy and completeness in reporting the case. Overall, the data collection involved a combination of field notes from the meetings, semi-structured interviews, documents and archives as primary sources of data, appropriately fine-grained for the main and the embedded units of analysis.

Focusing on the conduction of semi-structured interviews, respondents were chosen among individuals who could fully and reliably answer the questions. Essential criteria for informants were thus a significant understanding of the challenges faced in the management of projects and an experience of organisational issues, specifically as regards integrating and connecting multiple sources and flows of knowledge in a project-based organisation. A degree of variability was privileged, aiming to select interviewees with different levels of seniority and professional backgrounds in order to analyse and identify patterns of perceptions, experiences and situated learning of the people within managing projects. In fact, using multiple respondents enhances validity (Yin, 2013) and reliability of the collected data (Voss et al., 2002). As shown in Table 3.5, in total 12 informants were interviewed. Focusing on the professional knowledge and the experience gained on the field, the respondents have between 2 and 18 years of experience in Fincantieri. They are mainly people belonging to the key roles in the project management teams (project manager, lead project engineer, controller, and planner, further described in Paragraph 4.3.1 of this thesis), employed in projects that were being delivered at the time of data collection. Moreover, the 9 people currently involved within the project teams had different professional paths, allowing to enrich the insights in terms of perceptions (and experiences) of project complexity and organisational learning. The 3 managers who were already involved during the meetings were further interviewed on some of the projects included in the sample. Due to their strategic roles within the business unit and their long-term experience in Fincantieri, these interviewees were among the best informed about the data being searched and, especially the planning and control functional roles, had the opportunity to access the enterprise resource planning system with a different level of detail.

Table 3.5 – Details of interviewees

N.	Actual role	Code	Years of experience	Actual position		Previous position		
				Functional (Business Unit)	Project management team	Same role	Other roles (Project management team)	Other roles (functional)
1	Financial Planning and Control President	FPC1	4	•				•
2	Financial Planning and Control Manager	FPC2	10	•				•
3	Project Managers Chief	PMC	5	•				•
4	Project Manager 1	PM1	7		•	•		
5	Assistant Project Manager	APM	7		•			•
6	Project Manager 2	PM2	17		•	•		
7	Lead Project Engineer	LPE	15		•			•
8	Cost controller 1	CC1	3		•	•		
9	Cost controller 2	CC2	2		•		•	
10	Planner 1	PL1	18		•			•
11	Planner 2	PL2	4		•	•		
12	Purchases Coordinator	PC	14		•		•	
	Total	*12*	-	*3*	*9*	*4*	*2*	*6*

At least one informant per project was selected (out of the 7 projects considered in the selection of the case). As shown in Table 3.6, 16 interviews were performed (with 4 informants interviewed on 2 projects). Basing on the topic of investigation and the aims of the study, the final number of respondents was reached considering the trade-off between breath (involving a larger number of informants) and depth (with a deeper and richer information from a smaller number of people) (Patton, 2002). In this case, the decision that saturation had been reached was enabled by the constant comparison of information during the data collection process (Glaser and Strauss, 1967), until adding other informants at the sample was not revealing new patterns or themes and additional data resulted in minimal incremental understanding (Lee, 1999).

Table 3.6 – Distribution of interviews in the analysed projects

PROJECT		INTERVIEWEE		INTERVIEWS	
N.	**Cruise ship**	**N.**	**Role**	**Number**	**Total number per project**
1	Music cruise ship	1	FPC1	1	4
		4	PM1	1	
		5	APM	1	
		8	CC1	1	
2	Skyline cruise ship	2	FPC2	1	2
		6	PM2	1	
3	Northern cruise ship	3	PMC	1	2
		10	PL1	1	
4	Panoramic cruise ship	2	FPC2	1	2
		12	PC	1	
5	Queen cruise ship	7	LPE	1	2
		8	CC1	1	
6	Inspiration cruise ship	1	FPC1	1	2
		11	PL2	1	
7	Eastern cruise ship	9	CC2	1	2
		6	PM2	1	
			Total number of interviews	*16*	*16*

Prior to conducting the interviews, an interview guideline was developed in order to ensure consistency and provide guidance during the data collection process (Given, 2008). Moreover, it was useful as a checklist to verify that all relevant topics were covered. The guideline was first designed in English and then translated into Italian. The Italian version was then edited and revised carefully to mirror the investigation framework underlying the English version. Two pilot interviews were conducted to test the design of the questions and validate and eventually adapt them in accordance with the needs of the research and the specificities of the informants.

The interviewing guideline was designed as semi-structured, including open-ended questions. The aim was twofold: providing the necessary level of control and consistency over the interview process and enrich the pre-set questions with follow-up questions to elicit further details on specific aspects of the research problem (Given, 2008). To be sure that all topics have been covered, the interview guideline – presented in Appendix B – was developed in order to cover the main areas included in the two investigation frameworks and informed by the literature on project complexity and organisational learning in project-based settings. At the beginning, the researcher provided the participants with an outline of the research topic, by providing a clear definition of complexity. While each person is expected to have her or his own understanding of project complexity (Cooke-Davis et al., 2007), people working in projects usually understand and use the term "complexity" in a very broad and diversified way, mainly due to the lack of awareness on the distinction between complex and complicated (Azim et al., 2010). Given the interest in practical issues linked to complexity and learning in projects, an important premise for understanding how the interviewees perceived the influences on their capability to successfully manage the project was by evaluating their subjective experiences. Therefore, each interview started with generic questions about the interviewee's roles and responsibilities, his or her overall professional background and work experience at Fincantieri and in other organisations, where applicable, the project currently carried out. In the following, the researcher asked broad questions and engaged in active listening to build rapport with the interviewee (Given, 2008). The first question, focused on the project history, was purposefully open-ended as it aimed to verify the individual understandings of complexity and other contextual factors within the project and whether the company presents a learning environment. Specifically, the researcher aimed to explore point of views and perceptions on the success and the structural and emergent features of complexity throughout the project lifecycle until that moment. As the interview progressed, the questions became more specific and detailed, enabling a further understanding of knowledge development by experience and acquisition, and further codification of it. Examples were provided to investigate factors, people and means which made the respondent believe that it was important to share and transfer the knowledge gained in the studied project to other, or at the opposite how project members shared and reutilised knowledge from other projects in the current one.

While the 7 key projects in the sample provided the first context of analysis, many informants referred to and discussed extensively their previous experiences and perceptions, both in terms of complexity faced in past projects and learning or knowledge acquired and retained. Overall, the pre-set and the follow-up questions were phrased in order to isolate and probe into the within and cross-project organisational learning. Interviews lasted between 60 and 75 minutes. All interviews were tape-recorded for transcription, analysis and interpretation.

Aiming to triangulation purposes for consistency of findings and mitigation of bias when studying a phenomenon (Patton, 2002; Voss et al., 2002; Yin, 2013), additional primary sources of evidence were used. The interview data were thus integrated with qualitative questionnaires, field notes from each interview and each meeting, documents and archives. The questionnaires were administrated to the project management teams of the seven projects. Documentation used included the company's profile, plans and procedures of each project, the corporate governance, the informative profile drawn for the IPO in 2014, statements of the company mission and vision, annual reports. Archival data were extracted from the enterprise resource planning system, while publicly available company documentation was retrieved from sectorial newspapers and the company website. News articles, press releases, books (e.g. Galisi, 2011), literature and technical reports on the shipbuilding sector (e.g. European Commission, 2009) were also considered.

Finally, the researcher had the opportunity to attend the presentations gave by two of Fincantieri project managers (working on cruise ships projects). Both presentations featured numerous references to the topic of project complexity and project management practices (e.g. risk management) to deal with, and implicitly to organisational learning.

All the sources employed in data collection phase are summarised in Table 3.7.

Table 3.7 – Sources of evidence for the case study research

Type of source	Source description	Collected data (main topics)							
		Shipbuilding industry	Company profile	Merchant Ship Business Unit profile	Project management (process, practices. teams)	Multi-project complexity dimensions	Project complexity dimensions (single)	Within project learning	Cross-projects learning
Primary sources	Preliminary meetings	•	•						
	Semi-structured interviews						•	•	•
	Follow-up meetings		•			•			
	Field notes			•	•	•	•	•	•
	Qualitative questionnaire					•	•	•	•
	Publicly available documentation		•	•	•				
	Archival data			•	•		•	•	
Secondary sources	News articles, press releases		•						
	Books	•	•						
	Literature and technical reports	•	•			•	•		
Events	Company presentation at University of Udine		•		•	•			
	Company presentation at Italian PMI (Project Management Institute) national forum	•		•	•	•			

3.8 Data Analysis

The material gathered during the phase of data collection was organised to highlight facts, elements of complexity and mechanisms for organisational learning for each project and the overall company (then specifying the business unit under investigation). A database was prepared for each unit of analysis (single projects and broader firm level), consisting of the transcripts of all interviews, the field notes and the relative documentation (including primary and secondary sources).

Interviews were first transcribed in Italian and then translated into English. The English version of the transcripts was used to analyse the data and extract examples of data incidents in support of the findings.

Constant interactions were made between data collection and analysis during the first period. As the collection of additional data resulted in minimal incremental understanding (Lee, 1999), the data analysis was the prevalent activity. This was informed by a pattern-matching approach. Moreover, gathered data were organised and further analyses accordingly to the investigation frameworks described in Paragraph 3.6. Theoretical comparison and emerging findings were reviewed and refined accordingly. During the process of data collection and analysis, the researcher shared and checked the interpretations of the data in the follow-up meetings with the participants, giving them the opportunity to discuss and contribute with new or additional perspectives on the issues under investigation.

The pattern-matching draws on Gioia Methodology, which seeks to bring qualitative rigour to inductive research (Gioia et al., 2013). A basic assumption of this methodology is that participants are viewed as "knowledgeable agents" and "people in organisations know what they are trying to do and can explain their thoughts, intentions and actions" (Gioia et al., 2013: 17). Data are distinguished in first-order data, corresponding to informants' views, and second-order data. Primary coding was taken in-vivo (i.e. in interviewees' language), then secondary coding was undertaken using scholarly terms drawn from theoretical concepts. From these stages, a model is then developed. Both primary coding of in-vivo terms and secondary coding of theoretical terms was undertaken manually. Following the analytic technique of pattern-matching, similarities and differences between data incidents and groups of codes were identified (Eisenhardt, 1989; Yin, 2013).

For the sub-units, data were analysed following a two-step procedure: within-case and then cross-case analyses (Eisenhardt, 1989; Voss et al., 2002). Firstly, a within-case analysis for each of the projects was conducted, creating a detailed case study write-up. For each individual sub-unit in the study, data were analysed at both the single project and the business unit level, and these analyses were followed by an investigation of the relationships between the levels. The tables developed per each case in Paragraph 4.4 categories and detail the important conditions (McCutcheon and Meredith, 1993). Secondly, a cross-case analysis allowed to propose a common operationalisation of dimensions of project complexity and to identify patterns in the organisational learning processes. The phase of results comparison also took place firstly at the sub-unit level of cases in order to reflect the embedded nature of the cases.

The results of the embedded case study are reported in Chapter 4, while the discussion is presented in Chapter 5.

CHAPTER 4. RESULTS

4.1 OVERVIEW OF SHIPBUILDING INDUSTRY

Aiming to better understand the motivations that led the major choices in Fincantieri in terms of organisational settings and project management processes, it is essential to provide a brief overview of the shipbuilding industry. In the following, main issues in terms of product features, historical evolution of the European shipbuilding industry, main actors and phases of the building process are outlined. The "very special characteristics of the shipbuilding industry" (Vishnevskiy et al., 2017: 195) are discussed in the light of the interests of this thesis, i.e. the complexity and the learning dynamics in projects and project-based organisations.

From a historical point of view, the prominent European shipbuilders have seen dramatic changes during the last five decades (Graziano et al., 2016). In 1960 the shipyards of the European Community countries accounted for half of the world production of vessels. A few years later the production of ships from Japanese yards grew until becoming seriously competitive, summed up with the entrance in the international market of shipbuilders from developing countries such as South Korea. The petroleum crisis in 1973 and the following economic recession led to the loss of momentum in the worldwide demand for ships and a massive number of laying-ups and cancelled orders. European shipyards had to face at the same time the cost leadership of Japanese and Korean shipbuilders, a large excess production capacity and the following crisis of the market, especially for merchant vessels (Guisado-Tato et al., 2004; European Commission, 2009). In all the European Union countries, the demand decreased in almost all market segments (including the cruise ships), with the number of orders falling by almost 80% in a two-year period. Prices fixed in the bids for the delivery of new ships declined further and remained at their lowest for more than a decade.

Aiming to prevent the European shipyards bankrupt, the European Community promoted a series of socio-economic measures for the improvement of the framework conditions of the shipbuilding industry through the coordination of national aids. The Community support for aid to shipbuilding during the 1980s and 1990s allowed the undertaking of important restructuring processes and made it possible for the European industry to become more competitive (European Commission, 2009). Shipbuilding is a global business (Ruuska et al., 2013), which has been often considered a key strategic industry in many countries, becoming a national priority industry for the support of governments with multiple forms of socio-economic interventions (Pero et al., 2015; Vishnevskiy et al., 2017).

The restructuring processes undertaken to face the demand uncertainty were mainly based on the externalisation of part of the shipyards value chain activities and the subscription to cooperation agreements. As European shipbuilders could not compete with the Far East due to the high labour costs, several naval plants closed (Guisado-Tato et al., 2004). Nevertheless, the majority chose to retain the competitive edge and market share in the production of highly specialised, high value-added ships (Graziano et al., 2016). European actors were able to develop core capabilities to become strong niche players in specialised high-end markets (such as yachts, cruise vessel and specialised offshore markets), while propped market segments (including bulks, container ships and in general larger vessels) had tended to be led by Asian competitors (European Commission, 2009; Graziano et al., 2016). This specialisation has made European shipbuilding industry more resilient and less vulnerable to the enhanced capacity of Japanese and Korean shipyards thanks to factors such as their relatively low costs of steel and labour force. Moreover, the European industries are in general strong in innovation, with an important position of Small and Medium Enterprises, also in marine equipment. European shipbuilding industry is still well-renowned for its high-quality deliveries and an efficient cooperation between marine equipment manufacturers and shipyards. (European Commission, 2009; 2013).

After a long-lasting period of growth and a high new-building demand, reaching a peak in 2007, the worldwide financial and economic crisis impacted both shipping and shipbuilding industry. The serious impact on the production of vessels happened only two years later, due to the long-term horizons in this kind of projects. The shipbuilding deliveries exceeded the new orders in many consecutive years. The double-digit fall in investments – due to the low demand rates in the seaborne trade – resulted in the impossibility to feed the production capacity and in a subsequent decline in prices.

Nowadays, European shipyards are leading the worldwide market in the specialised complex segment. Shipbuilders like Fincantieri preserved their niches and looked for the opportunities arising in other niches characterised by positive market prospects, high technological content and promising innovation rates such as the offshore one. The main actors in the industry succeed in pursuing a strategy of diversification to retain long-term competitiveness and enhance technologic capabilities through the cross-fertilisation between niche sectors. This resulted in the development of an "outstanding ability to design, manufacture and build the full range of high-tech vessels and maritime structures which meet the most stringent safety and technical requirements, allowing the continent to engage in global trade, exploit resources and when the necessity has arisen, defend its strategic interests" (European Commission, 2013). The companies operating in the maritime sectors are also building integrated value chains of specialised suppliers and international networks to reach higher innovation rates, an increased flexibility and a stronger global presence. Current innovations are mainly focused on the greening and the safety of the vessels, extending the practices to the value chain as a whole end enhancing the competitiveness of the industry at a systemic level. The aim is twofold: meeting the higher standards, and leveraging on the European policies and supporting measures for the exploration and exploitation of opportunities along these core themes. Shipbuilding companies are then constantly starting initiatives towards issues of green and social responsibility with the introduction of new technologies into their business processes and also those of their supply chain partners (Caniëls et al., 2016; European Commission, 2012).

The European shipbuilding industry has a longstanding tradition in the project-based production (Levering et al., 2013). Indeed, the shipbuilding sector is also an example of a project-based industry (Bresnen et al., 2004; Romano et al., 2010). The development of a new ship is organised as a project, each extremely large in scope, including several work packages and involving non-routine production processes (Bresnen et al., 2004; Gann and Salter, 2000; Ruuska et al., 2013). Project management requires the integration and coordination of numerous activities that involve a large number of stakeholders, high levels of uncertainty, and often have a long duration (Leufkens and Noorderhaven, 2011; Romano et al., 2010).

Individual ships have to be tailored to the unique requirements of each customer (Davies and Brady, 2000), i.e. the shipowner. Each vessel has its particular characteristics which distinguish it from another and they are usually produced in a small series of two to six units. Even ships from the same series differ from each other, according to specifications mainly determined by the shipowner demands and wishes (Mello and Strandhagen, 2011; Mello et al., 2015; Romano et al., 2010). Indeed, shipowners request a high variety of ships with different purposes to respond to the ever-changing market of seaborne transport, which is strongly affected by the choices of the final users and by the ongoing globalisation of economies, markets and value chains (Vishnevskiy et al., 2017). The high level of customisation leads to an even higher involvement of the customer and in general, the network of stakeholders in possible modifies to the ship design for the duration of the product development and project implementation process (Davies and Brady, 2000).

Ships have complex product structures (Mello and Strandhagen, 2011; Vishnevskiy et al., 2017), partly determined by the high level of customisation. From a technological point of view, building a ship represents a large investment for the whole supply chain (Caniëls et al., 2016). The diverse activities performed during a project – design, engineering, procurement, manufacturing, assembling and commissioning – are identified as engineering-to-order (Mello and Strandhagen, 2011) and require modularity (Vishnevskiy et al., 2017). Each ship is composed of several ship sub-assemblies, each one consisting of a high number of components, built separately and then assembled (Romano et al., 2010). Many markets require extremely large or specialized equipment, such as docks and cranes (Greve 2003). The technological sophistication is one of the main factors linked to the increasing level of outsourcing adopted (Mello et al., 2015).

The design and construction of a vessel, the long-time duration of projects and the usually large scope of the production require to assign the work packages to different shipyards and part of them to be purchased to external suppliers or outsourced to a network of subcontractors operating worldwide (Bresnen et al., 2004; Caniëls et al., 2016; Ruuska et al., 2013). Up to 80% of the value of a vessel is outsourced to partners and subcontractors (Mello and Strandhagen, 2011), reaching a really wide and heterogeneous network of actors involved (Romano et al., 2010). The several hundreds of participating organisations that, in addition to the joint goal of delivering a ship satisfying the requirements of the shipowner, are directed by their own business goals that may conflict with the goals of the network (Ruuska et al., 2013). There is a risk that the horizontal and vertical differentiation within individual organisations, the degree of uncoupling between project activities and the wider organisational strategies and the diverse institutional practices and norms become a very important influence on project management practices (Bresnen et al., 2004).

This affects also the learning dynamics within the industry and especially the value chain. Each contractor usually adopts different production methods, with diverse levels of organisation and technology, and therefore attaches different priorities to the working method in collaboration with the actors of the network (Pires and Lamb, 2008). The connections between the activities are quite tight and most of the activities are carried out on-site (within the limited space of the shipyard), making site management a crucial issue (Pero et al., 2015). Shipbuilding is one of the most complex environments for decision making (Romano et al., 2010). Projects are under time and pressure and require both creativity and cooperation, which reflects a dynamic process involving non-linear procedures (Antoniadis et al., 2011). Massive flows of accurate and timely information are then required to reduce uncertainty (Ruuska et al., 2013). Moreover, a higher involvement and information exchange during the key phases enable to accommodate customer changes and to quickly react to its requests (Pero et al., 2015).

The shipbuilding industry has always been a capital-intensive business requiring heavy engineering and significant technical and management expertise (Graziano et al., 2016). A high degree of engineering work is required to adapt an existent design or create a completely new one in order to fulfil customer requirements (Mello et al., 2015). Nowadays, shipbuilding has developed into a knowledge-intensive industry (Vishnevskiy et al., 2017). There is the need to improve the relational capabilities of the network of actors (starting from the shipyards and the suppliers of the core sub-assemblies) for a common ground leading to economies of repetition and transfer the learning to forthcoming projects (Brady and Davies, 2004; Davies and Brady, 2000; Ruuska et al., 2013). Moreover, Graziano et al. (2016) demonstrate that the shipyard know-how is the factor that mostly can affect the quality of the shipbuilding process. The shipbuilder leads each project, acting as both prime contractor and system integrator (Sauerhoff, 2014), and is ultimately responsible for delivering the finished vessel in time and according to customer specifications (Ahola et al., 2008).

4.2 Overview of Fincantieri and the Merchant Ship Business Unit

As stated above, the construction of complex vessels is strongly dominated by the European shipyards. Among the main players, Fincantieri is the world leader in the cruise shipbuilding segment by pursuing a niche strategy that has resulted in a solid track record of over 75 delivered cruise ships since 1990. Beyond the innovative design capability, the constant orientation to research and innovation activities that enable to follow and anticipate the demands of the market and the delivery of products and services characterised by the "Made in Italy" and a high-quality level, Fincantieri is well-known for its project management capability and the production flexibility.

This section further outlines the issues linked to the management of shipbuilding projects in Fincantieri, starting from the overview of the company summarised in Table 4.1 and the description of the competitive environment and the historical evolution. Indeed, current project management practices and misfits while coping with project complexity should be understood in the light of the contextual and historical developments (Engwall, 2003).

Fincantieri introduced the project management as a specific function within the organisation in 1990. The CEO believed since the beginning to the benefits of project-based organising, renewing the organisational structure after the crisis of the Eighties. It was judged as necessary to abandon the role of a generic shipbuilder, mainly committed to Italian shipping companies and till 2000 supported by governmental subsidies, in order to guarantee the survival in the market. Originally, the project management teams were constituted by a not-fixed mix of competences, in a sort of task force that resulted in an initially low efficiency. Moreover, the organisational centralisation adopted in 2009 was motivated by the need of limiting the internal expenses after the worldwide crisis. In 2015, the top management promoted the subdivision in 3 strategic business units, i.e. *Shipbuilding*, *Offshore* and *Equipment, Systems & Services*. The first division includes the Merchant Ship Business Unit, which develops and builds the cruise ships, leveraging on the price improvements in cruises. This change contributed to the growth in the cruise shipbuilding sector and the success as the first Western shipbuilder, with a leadership sustained by the over 50% market share.

Nowadays Fincantieri keeps on investing on internationalisation of the company, starting from the acquisition of foreign production sites, and the continuous improvement of its technological know-how, progressing on the design and production on high-tech, highly customised cruise ships (Galisi, 2011). This strategy needs to be sustained by maintaining a strong project management capability while dealing with the complexity of its projects and environment. In the following of this dissertation, Fincantieri will be mentioned referring the only Merchant Ship Business Unit and its cruise ships projects.

Fincantieri has a core capability as a system integrator. It operates with an integrated production model that, in addition to an advanced industrial system, relies on a network of suppliers that are specialised, often long-term dedicated, trusted and accredited. Suppliers are carefully selected according to factors such as the reputation, the level of confidence built up with the shipyards staff and the avoiding of situations where there is asymmetrical information due to power unbalance. For every ship that is built, different subcontractors of different specialisations can be selected, apart from the suppliers already selected as strategic. As the building phase includes a wide variety of high-technology activities, these activities are usually fully externalised or carried out through cooperation agreements. This ensures a considerable flexibility and efficiency in terms of both quality and price. Moreover, the superior system integrator capabilities carried to a proven track record of on-time deliveries.

Fincantieri produces internally the hull and then integrate all the professional skills needed to produce a ship. Building on a strong expertise on the final product, it coordinates a wide network of suppliers for each stage. The necessary search for cost reduction and timing of the vessels design and development process has led the development of a business model characterised by a high degree of flexibility and integration of the main business processes, and consequently a strong focus on the programmes and project management processes. There is a high level of outsourcing in the phases of design, procurement, production (where almost three-quarters of assets are outsourced) and warranty. The company adopted a make-or-buy strategy for each stage of development and implementation of the ship. The strategy aimed to develop core competence and ensure internally the high value-added activities while outsourcing to qualified suppliers the activities judged as non-essential or with a minor added value. The outsourcing of many activities, particularly in the areas of design and production, is also aimed at effectively and efficiently managing the fluctuations in workload and optimising the saturation of the company resources. For example, the executive design is coordinated and implemented internally, while the detail design (i.e. outfitting, furniture and sub-contractors) is outsourced. For this aim, the company leverage on the extended network of designers. To sustain the substantial number of employees reached with the satellite activities of the shipyards, the company has reached several innovative agreements with the trade unions. These allow to increase flexibility and continue developing products characterised by high innovation rates and in line with the highest standard, e.g. the ones on the greening issues.

Beyond the many interfaces with the suppliers and subcontractors network, the relationship with the customer is another point to consider when focusing on the project stakeholders. From the entry into the cruise ship business in 1990, Fincantieri has delivered (and has under construction) more than 100 ships to its customers. Among them, the Carnival Group is the world's leading cruise operator and Fincantieri is the main supplier of its cruise ships, leveraging on a long-term relationship. Carnival has a fleet of over 100 ships distributed among its several brands, including Carnival Cruise Lines, Costa Crociere, Cunard, Holland America Line, P&O Cruises, Princess Cruise Lines e Seabourn, Cruise Line. Moreover, Fincantieri has implemented a strategy of portfolio diversification that enabled to establish business relationships with other leading global cruise business operators such as Compagnie du Ponant, Hurtigruten, Disney Cruise Lines, Oceania Cruises, Regent Seven Seas Cruises, Silversea Cruises, Viking Ocean Cruises, Virgin Holidays Cruises. The global market of the shipowners is concentrated, with few major players, and this implies a low supply power for Fincantieri. From the other side, the contractual relationship with fewer players allows to deliver a better service and to approve customer requests for changes.

Moreover, Fincantieri is a large project-based organisation. As a corporate, it allocates shipbuilding projects to the network of shipyards and organises a vast flow of people and resources both across the shipyards and between these and the overall parent company. The production plan must optimise the utilisation of the shipyards, due to their limited capacity: the dry dock is the scarce resource qualifying a shipyard and the most important requirement to consider when allocating the constructions. Each production site can host only one ship at once, and they must work in parallel in order not to lose efficiency. When designing a vessel, the logistic constraints of the shipyard manufacturing are among the factors to consider. A cruise ship is a complex product with a value (from the shipbuilder side) of 500 up to 600 million € and a project to deliver it has an average lead time of 3 years. Its ability in implementing adequate project management activities and effective procedures and actions to control the correct completion and efficiency of the shipbuilding processes is the base of the constant growth in revenues and profitability. The project management process allows to adequately handle the complexity of the product diversification and the distribution of workloads based on production capacity (plant and workforce) available at the production sites.

Table 4.1 – Overview of Fincantieri

UNIT	KEY FEATURES
Industry	• Project-based industry • Complex products • Shipyard is the main actor within the supply chain • Strategic choices between low costs (Eastern shipbuilders) and niche and specialisation (Western shipbuilders)
Company	• Founded in 1959, from the late 1980s in the cruise ships market • First Western shipbuilder • System integrator and prime contractor • Project-based organisations, with three main business units
Customers	• Shipowners (diversification) • Cruises market: - Growth of demand in the final market (cruise tourism), with a recovery from 2014 - Few competitors - New entrants (e.g. Virgin cruises) and new brands (e.g. Costa Asia)

4.3 PROJECT MANAGEMENT AND COMPLEXITY IN FINCANTIERI

The project management function was created at the level of the other functions, as an autonomous structure. By overcoming the conceptual role of an expeditor and in general of a process that supports the other functions, the project management is the main actor in the project of a cruise ship. Following the matured experiences, the structure has changed over time and is constantly modified, aiming to satisfy the requirements of change while facing the increasing complexity and dynamics of the market and the shipbuilding sector. Nowadays, Fincantieri constantly improves its ability in project management, by widening and deepening the knowledge of the practices, the methodologies and the tools for an efficient and effective management of its projects. The investment on a strong project management function is also demonstrated by the resources allocated to the project management team: one team is dedicated to each project and in general to the overall programme defined with the shipowner. Indeed, each project involves the design and production of a single vessel that is included within a series. The orders for the construction of cruise ships include long-term contracts with a duration that varies depending on the size and the number of ships to be delivered, resulting in a level of uncertainty that is also linked to the uncertainty of the programme as a whole.

Fincantieri needs to implement project management activities that are adequate to face the operational complexity resulting from both the inherent characteristics of shipbuilding activity as well as the diversification of the organisation in terms of operating divisions, products and geographical location of the production sites. Leveraging on its capability of system integration, Fincantieri has been able to react to the challenging conditions of the cruise ships market by implementing a rationalisation program aimed to integrate the production sites and centralise a number of key processes. The project management process integrates and supports the other core processes, i.e. contract acquisition, design, procurement, production (and other support processes), as shown in the figure below.

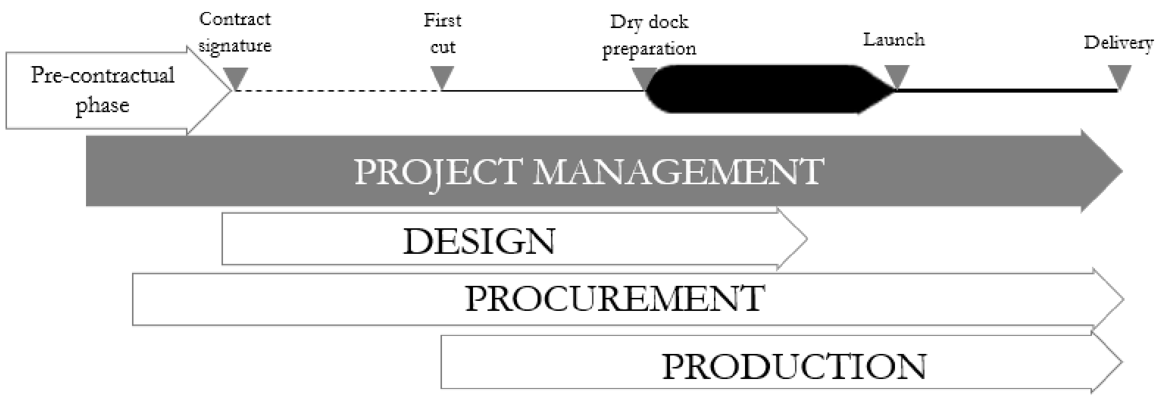


Figure 4.1 – Core and support processes in cruise ships projects

At the handover, the project manager is appointed and receives from the General Direction the order specification and a series of technical documentation describing all the contents of the ship. The involvement of the project manager during the acquisition phase enables a direct accountability of the role who will follow the project already in the budget definition. After that, the project manager and the General Direction jointly define the project management team and the staff within the technical disciplines that will be the reference for the project. At the same time, programmatic and costing elements are set up and potential criticalities of the project are highlighted on the basis of the content defined in the contract. The identification of the possible paths thus enables the enactment of those actions that are expected to minimise the impact of the most critical or less defined aspects during the implementation phase.

The design and engineering phases are the most prominent ones in terms of efforts, documentation and implications on the other phases. The amount of documentation supplied during the engineering phase overall is equivalent to tens of thousands of technical documents. The engineering phase employs over 600.000 hours for a prototype ship, which is also characterised by the significant content of engineering. The functional engineering aims to define the two-dimensionally content of each installation, then the construction engineering translates it into volumetric measures in order to guarantee that there is an integration between the hull and the development of the technical installations and furnishing. Concurrently, the supply activity defines the orders starting from the most important ones, as the engines, up to the pipes convention, which is stated especially for each project. The details that are not defined in the contract are fixed throughout the evolution of the project with the support and the changes introduced by the customer, the registers and the suppliers network.

The production cycle of a ship is composed of three core phases: the so-called *workshop* (pre-manufacturing and pre-assembly), *dry dock* (hull assembly and pre-outfitting) and *dockside* (outfitting and sea trials). The phase of workshop begins with the first steel cutting, celebrated with a symbolic ceremony, and consists in the cutting, moulding, erection and welding of blocks. Each building block is composed by sub-assemblies that are fabricated by other departments and a network of suppliers, then integrated and assembled in block joints following the concepts of modular construction. The hull is directly constructed within the shipyard. The phase of pre-assembly and pre-outfitting allows performing a sequence of activities that are parallelised and optimised to build a sample of building blocks already including all the installations, cables and pipes for the basic functioning of each of them. The pre-outfitting, the pre-assembly, the modularity in the construction and the alignment of the blocks are among the principal factors that determine the workshop as the phase where the company is able to reach the maximum level of productivity. The resulting blocks are laid at the base of the dry dock with the second phase of manufacturing, namely the *dry dock*. The dry dock is the element qualifying a shipyard as it represents the scarce resource. Here the sections of the ship are assembled and welded by following a strict sequence. Once the basic technical systems are fitted and welded with the hull, the dry dock is filled with water and the ship is launched. Here begins the third and last key phase of the production cycle, namely the *dockside*. The ship is moored next to the dry dock in order to complete the outfitting of the technical installations and to realise the assembling of all the furnishings, the public rooms, the common spaces and the cabins, which constitute the so-called *payload area*. All the fitting-out operations are carried out inside the ship in restricted spaces, and many of these include turnkey products. In parallel with the setting up, the painting and caulking activities are completed. One of the key stages ahead of the final delivery is the sea trials, where the staff of Fincantieri and the ship crew leave in the sea for four to seven days – depending on the degree of prototyping of the ship – and test the behaviour of the ship as well as the performance of each of the several systems during the operational phase. The production phase ends with the delivery of the vessel to the shipowner with the concurrent signature of the document named as the *protocol of delivery*, where it is represented the real qualitative and quantitative result of all stages of construction and testing. This formalisation is preceded by the release of the specific documents and certificates of the entities and of the competent authorities, e.g. the registers. Overall, the production cycle can last until 18 months, following a period of 12 to 18 months (for a prototype ship) of the design and engineering phases.

The following sections further details the roles and responsibilities of the project management unit (and specifically the teams) and the main dimensions of complexity to be faced in the management of a project aimed to deliver a cruise ship.

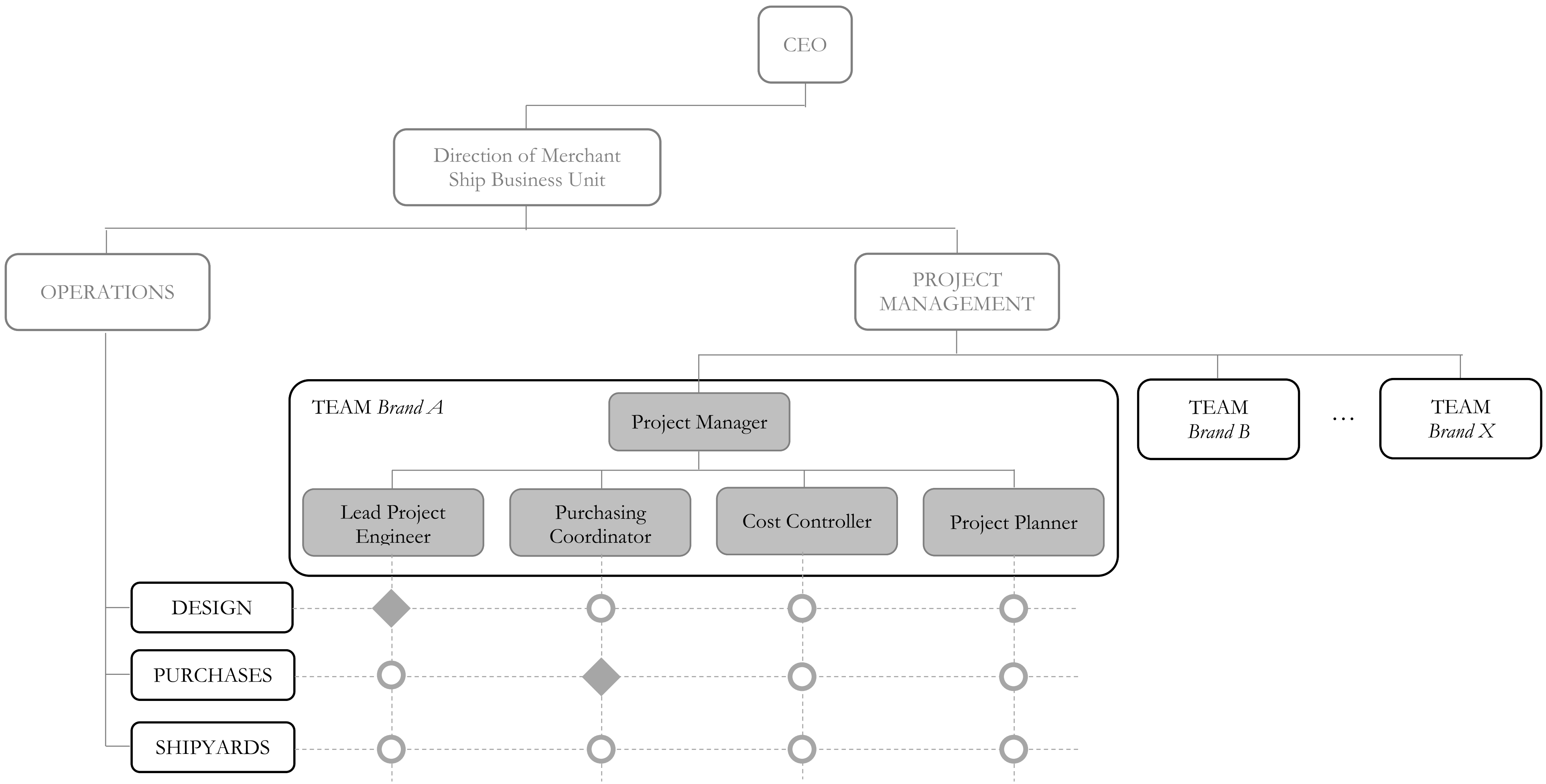


Figure 4.2 – Organisational structure and interfaces in Fincantieri Merchant Ship Business Unit

4.3.1 The project management unit and teams

Focusing on the organisational structure, the Merchant Ship Business Unit reports directly to the managing director. As shown in Figure 4.2, the business unit includes, in turn, two units: the operations and the project management one. The operations include in turn the three functions that directly manage the development and construction phases according to the scope of competence, i.e. the design, the purchases and the production, the latter including all the shipyards in which the ship will be manufactured. The project management unit reports to the manager of the project managers (i.e. the project managers chief) and has several interfaces with the functional staff in order to manage the project itself. Each project management team is usually dedicated to one project at a time, and in general to the overall programme defined with the shipowner. Indeed, each team is usually customer-oriented, with a strong focus on the brand of the shipowner, aiming to ensure a long-term relationship with the customer through the same interfaces. Internally, each project team is named according to the brand is working with, e.g. the team *Carnival* is managing the project for the delivery of one of the cruise vessels included in the contract with the *Carnival Corporation*, one of the historical Fincantieri customers. In Figure 4.2 we simply name the teams with incremental numbers.

The interfaces between the project management function and the functions directly involved in the development and construction phases are manifold. The main internal aspects to be considered within the project management tasks are the identification of the human resources to be involved and the goals to be achieved. The process of definition of the programme objectives, coherently with the project milestones, is performed in cooperation with the functional managers, which are in charge of further specifying the programme into the detailed operative programmes of each function. The identification of the economic goals consists in the draft of a sort of internal contract between the project management team and the functional departments – purchases, design and production (i.e. the shipyards) – that constitutes the reference for the definition of responsibilities, the measurement of the achievements and the monitoring of the activities progress throughout the project lifecycle.

A project team is usually constituted by 15 to 20 people, basing on the managerial complexity of the project. The project manager is appointed and is accountable to the company for the overall performance of the project in terms of time, quality and especially cost. Each project manager reports to the manager of project managers (or project managers chief). Being in charge of delivering the project successfully, the project manager owns the authority to intervene in particularly awkward situations. Moreover, he or she is the reference person for the shipowner team, with a further responsibility in terms of interfaces and communication approaches. Generally, project management teams are customer-oriented (i.e. one team per customer) and tend to manage all the projects included in a contract with an only shipowner.

The project manager coordinates and strictly collaborates with four key roles that distinguish the resources with specific capabilities in terms of project planning and control, risk management, contract management, compliance monitoring and project progress. As shown in Figure 4.2, each project management team is led by a project manager and includes the key roles identified as Lead Project Engineer or LPE, purchasing coordinator, project planner and cost controller.

The LPE represents the most important technical reference both to the company and the shipowner, as it guarantees that the configuration of the ship meets the contractual specifications defined by the customer. He or she is responsible for controlling the project development at all stages, therefore this role is also the technical interface for the customer.

The second function within the team is the purchasing coordinator, who is the one that coordinates and manages the procurement process of the project ensuring consistency with the ship programme and the contract budget. The cost controller oversees the achievement of the contractual economic margin through the actively monitoring of costs advancement and the timely identification of variations (due to different contingencies) compared to the expenditure forecast. Another important task is coordinating the risk management process and the economic evaluation of events that have an impact on the margin throughout the project lifecycle. The costs structure follows the project WBS and takes into account the direct costs (e.g. the manpower within the shipyard), the indirect costs and all the subcontracted components and systems.

Finally, the project planner represents the "clock" of the project, as it defines the master schedule on which basing the development of the detail programmes and their consistency and alignment to the overall objectives fixed in the ship programme. The planner is thus responsible for coordinating, integrating and monitoring the single programmes of the involved design, purchases and production departments.

Overall, the project management unit, specifically with the figure of the project manager, is in charge of:

- at the beginning of the project, performing a detailed analysis, with the support of the Lead Project Engineer, of the contractual documents and verifying their completeness and consistency to further proceed with project development;
- analysing in detail the "budget plan", identifying any criticalities or risks, promoting further improvement actions, and defining the appropriate make-or-buy strategies for the supplies, thus developing the "operational plan" for the project;
- preparing and agreeing with the design, purchases and production (i.e. the shipyard) departments the internal service contracts, which divide the "operational plan" according to the responsibilities and discipline the assumption of reciprocal commitments between the project manager and the functions in terms of cost, planning activities and improvement actions. The negotiation between project managers and functions is aimed at sharing and mutual accountability on the goals, setting up the technical and economic reference baseline for the control of the project development and the synchronisation of the project planning between the different functions;
- validating the pre-planned target programme for the project that has been developed during the budgeting process and develop the master plan as a reference programmatic document for the development of functional programmes (design programme, architects programme, supply programme, production programme), monitoring the following evolution and managing the deviations, in conjunction with the functions, through the project meetings and the further stages of verification;
- managing the risk plan of the project defined with the support of the other functions;
- being the reference for all the relationships with the customer relating to the contract, e.g. in managing project change requests, approving new supplies, and managing further relevant technical issues;
- controlling, coordinating, and integrating the activities of the functions and the third parties involved in the project development, identifying the criticalities and overseeing the resolution process in order to minimise impacts to preserve the achievement of the contract goals;
- ensuring the overall economic and financial control of the project (including, for example, overall results, advances, quarterly forecasts and improvement plans);
- checking the compliance with the objectives that have been set in the project quality plan, by monitoring key quality indicators and requiring, in critical cases, appropriate remedial actions to the relevant functions.

To sum up, the project managers and their teams are responsible for the overall performance of a project throughout the life of the contract, from the acquisition of the contract to the ship delivery, including the following warranty period. Each project team can be compared to a "small company" where the core competencies are structured and balanced between a technical (with the LPE), an economic (with the planner), and a purchasing (with the purchasing coordinator) competence. The prevalence of managerial or technical background required for these roles depends on and is properly mixed to support at best the project manager and the know-how required in the development of a specific project. Indeed, the abilities vary according to the level of technological uncertainty and the type of customer. Each of the key roles interfaces with the reference people in the functional departments in different ways, according to an organisational matrix structure, which is common to most of the project teams. While the project planner and the cost controller coordinate the process but not the resources, basing on simple interfaces with all the functional staff, the purchasing coordinator and the LPE have directing roles. The LPE coordinates a team of specialists within the design department, which includes one expert for each technical discipline (e.g. the hull, the engine, the power supply system, etc.). The purchasing coordinator integrates the numerous budgets of the purchases department. This structure guarantees a strong control on the engineering, while the relationship with the production (and then the shipyard staff) is limited to an interface.

> "There is a much tighter relationship with the shipyard, somewhat for our culture and for our history – not by chance our company name is Fincantieri, where the shipyard plays a fundamental role. Many times, conflicts take place to achieve the result of the project, precisely because their sight it is not just that of the single project itself." (PM2)

Basing on the lesson learned throughout its history and the recent evolutions, Fincantieri is further reconfiguring the organisational structure by including the functional staff responsible for the project (one specialist for each system included in the WBS) under the project manager responsibility, i.e. in a strong matrix configuration. Due to their strategic relevance within the company projects portfolio, the enlarged project management teams respond directly to the responsible of the Merchant Ship business unit. This organisational configuration has been adopted in the most recent projects (i.e. project 1 and 3, as described in the following).

4.3.2 Dimensions and elements of complexity in a cruise ship project

The main elements of complexity in a shipbuilding project are the type of product, the process, the high number of stakeholders and the goals that the process itself has to achieve (organisational).

Focusing on the product, the cruise ships are large, complex, technologically advanced and with a significant economic value. They can be compared to a "sailing city" with a length that can overcome the 300 metres and an extension of indoor public rooms for 24.000 square meters, adding up the external ones for another 9.000 square meters. The value of each ship can overcome the 600 million euros. It integrates different kinds of systems and a number of non-naval technologies. The systems and sub-systems included in the WBS differ from the ones of a standard vessel, starting from the propulsion plant, usually diesel-electric and based on 4 to 6 engines, to the other onboard sub-systems such as the electric plant, the bridge automation systems and the air conditioning. Moreover, the structures for the basic functioning interface with the so-called "payload area", which is realised as a floating hotel in itself, aimed to host, entertain and safely transport up to 6.000 of persons. The design of each ship is developed basing on a technological platform, which is completely new and created from the scratch if the ship is a prototype one. Prototype ships are the first unit of a series and are characterised by a highly innovative content. The so-called sister-ships derive instead from a well-established platform of the hull, usually leveraging on a consolidated design as regards the basic structure. Usually, a contract with a customer establishes the production of up to 5-6 sister ships, remaining limited in number in order to maintain a high level of customisation and not to cause the obsolescence of the previous cruise ships. Although the opportunity of leveraging a common platform, the evolution of this kind of project requires a strong attention to the design and implementation of the WBS that will interface with the established platform, originating new elements of complexity. Beyond the development process, each project is embedded and interfaces the company structured organisation, where the hierarchical levels are a necessity to face the dynamically evolving market and the current trend of companies to evolve rapidly. From the socio-political or environmental perspective, each project (and the relative shipyard where is developed) has a strong connection with the satellite activities. Each shipyard is among the top employer of the local territory where it is based, resulting in important implications for the employment and the local economy. These strong interdependencies result in a further level of uncertainty when dealing with unexpected events such as strikes and local work disruptions, which can result in severe impacts on the pace of the project and the capacity required to fulfil it. Severe disruptions can be due also to climatic events such as earthquakes and hurricanes, which can affect both the shipbuilder and the customer, and delays in suppliers' deliveries. Finally, another key external aspect to be properly managed is the compliance with the regulations imposed by the ranking and the flag registers, especially as regards the norms on safety that require the introduction of redundancies, resulting in an increase in complexity.

Focusing on dynamics, the production process requires prominent levels of coordination and timing. Cruise ships construction projects are implemented over long-term horizons and usually in different production sites, whit two sections of the same ship constructed at the same time, requiring a multi-site coordination. Each project involves over 10.000 people and can be structured in more than 100.000 activities involving 2 million working hours in the shipyard. Significant figures are represented by the quantity of steel supplied for the production, which is equivalent to 4 times the steel used for the Eiffel Tower, and the length of all the cables that are aboard that can reach over 4.000 km. Moreover, the supply chain management is critical in both the design and production (in shipyards) phases, with constraints related to the available space and a tight schedule for the yard occupation. In addition to this, each shipyard is unique in terms of planning and controls, tools and constraints. The dry dock is the scarce resource of a shipyard, as its maximum capacity limits the number of consecutive ships to be produced in a year. The workload is among the key variables to be considered for planning the single project, taking into account the other projects to be carried out in parallel in the company's shipyards and the diverse types of resources. Throughout the production cycle, Fincantieri has the role of integrating and coordinating a large number of suppliers based in the shipyard, with a dynamic management of any modification before the final delivery. In the last few months before the due date, the integration and coordination efforts are even amplified with tighter schedules and less time for facing actively the possible problems and the changes. In the meanwhile, the level of uncertainty on the design phase reduces, with an adjustment on the construction tasks, resulting in a different level of complexity and therefore in a different decision-making process. For each project, throughout its lifecycle, quality and time are the main constraints. The main goal is to deliver a ship that fulfils the customer's expectations by the date scheduled by the contract. The due date is defined since the order and any delay would significantly penalise Fincantieri in terms of reputation and penalties, as a single day of delay in a delivery involves the payment of a penalty of half a million euros.

> "starting from the moment in which you have to realise a ship, to develop a project from the engineering point of view, to supply the material and to build a ship according to what a client demands, there is a contract that is clear ... the customer expects that on the day of delivery you will deliver him a ship that meets all the requirements that are written in more than a thousand pages of specifications in terms of everything, that is the ship's performance, the dimensions, the functioning of the installations…" (APM)

Finally, there is the goal of the costs that usually represents the harder to be achieved, especially in the recent years due to the difficulties generated by the worldwide crisis. Moreover, the project management team is in charge of achieving all the project goals, while the functions are generally focused on single performance indicators, as shown in Table 4.2. This results in a further level of uncertainty on the project success.

Table 4.2 – Different goals and perspectives in a cruise ship project

	Time	Cost	Quality	Description
Design department	+	-	++	Main interest towards achieving a good design, considering the quality perceived by the customer as the main target
Purchases department	-	++	-	Optimisation of the purchasing orders pricing (e.g. by aggregation)
Production (shipyards)	++	-	+	Delivery of the built ship on time, quality mainly as regards the functioning, not from the customer perspective
Project Management	++	+	++	Accountable for the delivery of the project on time, with respect to the budgeted costs and compliant to quality requirements

++ *very important*
+ *important*
- *less important*

From the managerial point of view, main elements of diversity are the shipyard and the customer, identified as the main stakeholders of a project. The main aspects to be managed are the interfaces with the shipowner and its network of architects and consultants, especially as regards the ship configuration, from the lighting to the catering. Indeed, these actors are the specialists in the logic of operating the ship that is beyond the know-how of Fincantieri, mainly focused on the construction aspects of the product. For example, as the public rooms are the elements qualifying the functionality of a cruise ship from the point of view of the final users, their design is realised by a team of architects, interior designers and other consultants for the furniture. Dealing with their high number and diverse approaches in drafting the layout of the rooms requires, in turn, a high number and variety of interfaces that have to be agreed in a programme of information sharing, aiming to guarantee an implementation that is coherent with the requirements of the ship configuration. Moreover, a major design change requested from the shipowner or its consultants needs to establish a formal approval process, where the respective cost and schedule impact is estimated and a variation order for customer approval has to be issued. This process can last up to a year, as it requires to estimate the impacts on the design (in terms of interfaces with the technical systems), the production (in terms of reallocation of the extra activities to be performed), the purchases (as regards new or modified orders) and to establish the value engineering process, aiming to implement the changes at a lower cost while guaranteeing the level of quality agreed with the shipowner. Moreover, the entity of the changes and the approval process can represent a risk for the delivery of the ship on time. For this reason, the pre-contractual phase is the first fundamental as it is the premise for a better organised and defined the start of the project management process. Fincantieri can assume a high probability that an order will be finalised once the first pre-contractual arrangements are managed, as the number of customers and the number of shipyards worldwide able to satisfy their request is relatively low. Nevertheless, the contractual phase can last from 3 to 9 months, as it allows to define all the ship contents and to finalise the economic price. With the acquisition of the contract at the conclusion of the bid phase, the handover takes place. There is a transfer of deliveries between the bid formulating manager and the project manager who will manage the subsequent development and implementation within the constraints established in the contract. Throughout the project lifecycle, the overlapping between the phases is relevant and represents another element of complexity as the project is mainly defined during its development (especially during the last phases before the final delivery).

Table 4.3 summarises elements of complexity of a cruise ship project according to the dimensions of complexity identified in the investigation framework (following Paragraph 3.6).

Table 4.3 – Dimensions of complexity in a cruise ship project

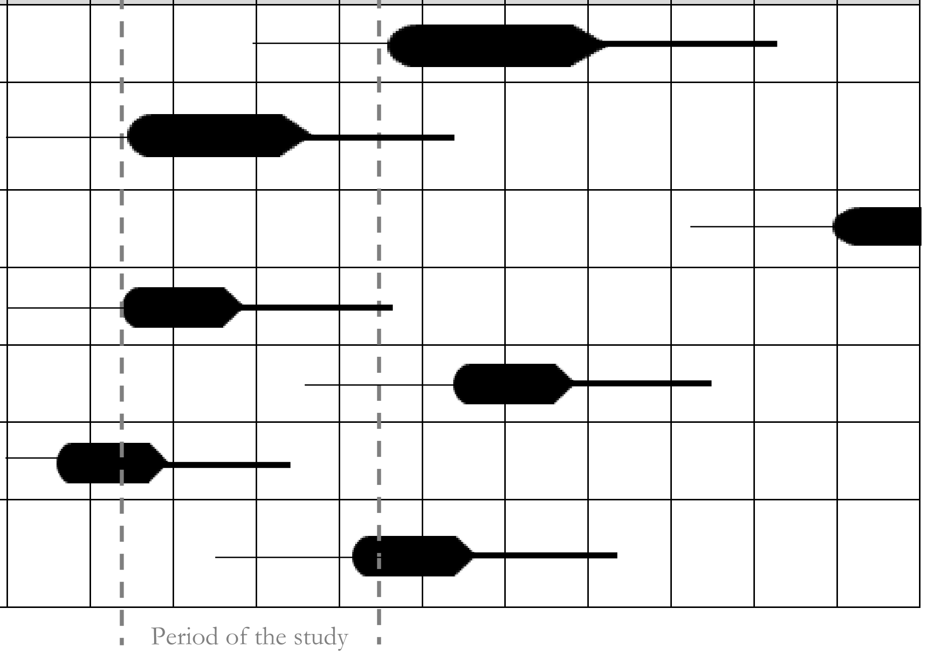
DIMENSION	KEY ELEMENTS
Diversity	Ship size High level of customisation Project uniqueness Competencies within the project management team Project management teams' experiences Professional roles and responsibilities Shipyards requirements
Interdependency	Client-oriented processes Interfaces with the shipowner Interfaces with the stakeholders Interfaces between the payload and the functioning area (ship layout) Projects portfolio (business unit) and contract (customer) Interfaces with the company hierarchical structure (between project management teams and other functions) Alignment on project goals
Dynamicity	Project boundaries Contingencies Customer changes Disruptions (e.g. climatic events) Delays in architects and supplies deliveries Compliance with regulations
Uncertainty	Prototype or sister ships Different perspectives on project goals Newness of the customer Impacts of customer changes Unexpected events (e.g. local environment)

4.4 COMPLEXITY AND ORGANISATIONAL LEARNING WITHIN PROJECTS

In what follows is a description of cases in the sub-units in order to contextualise the factors related to complexity in each project and the resulting learning process. Table 4.4 summarises the main features of each project (and the relative ship) selected in the study. Specifically, it outlines size and type of ship, the main shipyard where the manufacturing activities take place, the main project milestones, the graphical evidence of the temporal allocation of the study compared with the three main activities within the production site (the so-called *workshop*, *dry dock* and *dockside*).

Table 4.4 – Overview of selected projects (sub-units) with evidence of milestones

N.	Name	Shipyard	Type of ship	Main milestones			2015	2016		2017		2018		2019		2020	
				Dry dock[1]	**Launch**	**Delivery**	Jul - Dec	Jan - Jun	Jul - Dec	Jan - Jun	Jul - Dec	Jan - Jun	Jul - Dec	Jan - Jun	Jul - Dec	Jan - Jun	Jul - Dec
1	Music cruise ship	Western	Prototype	Nov 2017	Feb 2019	Feb 2020											
2	Skyline cruise ship	Daisy	2nd Sister, shipyard change	Mar 2016	Mar 2017	Mar 2018											
3	Northern cruise ship	Daisy	Prototype	Jun 2020	Mar 2021	Jun 2022											
4	Panoramic cruise ship	Eagle	Prototype	Mar 2016	Nov 2016	Nov 2017											
5	Queen cruise ship	Eagle	4th Sister	Mar 2018	Nov 2018	Oct 2019											
6	Inspiration cruise ship	Western	Prototype	Nov 2015	Jun 2016	Mar 2017											
7	Eastern cruise ship	Eagle	1st Sister, brand change	Aug 2017	Mar 2018	Mar 2019											



[1] It corresponds to the date in which the ship (made of assembled blocks) is laid at the base of the dry dock.

4.4.1 Project 1: Music cruise ship

At the time of the study, the project is entering the production phase, in the so-called workshop (pre-manufacturing and pre-assembly). The design and engineering phases have been challenging as the ship is a prototype one, and one of the biggest ever realised. Moreover, the dimension of the ship is also big for the production site where it has been allocated. This implies a further restriction on project constraints in terms of timing, as in case of delay no extra capacity can be supplied, and rigorousness in terms of respect of sequences and programmes is almost mandatory. This is an aspect perceived as an external factor for the management of the project, since it is not included in the possible levers within the implementation of a single project, rather than in a multi-projects environment. Focusing on the technical content of the ship, innovative technologies have been introduced during its implementation. The most important is the gas propulsion engine, which represents an innovation as it is the firstly implemented within the cruise ship building (despite the company has already a patent but in complementary products). Moreover, many technical installations have been introduced during the implementation of the project, mainly aimed to guarantee compliance with the energy saving requirements.

Focusing on organisational issues, the project management team is experiencing a new configuration, with the project manager as an

> "end-to-end responsible, that is from the beginning to the end of the entire project, linking the two worlds of the design and the production, and the managerial and technical areas" (PM1)

Two key roles have been included within the managerial area: the referee from the operations for the production engineering, who is responsible for the methods and activities sequencing of the shipyard, and the commission and quality engineer. In this way, a better interaction between the production and the design department is achieved, overcoming the disagreement on the project goals. Within the technical area, the technical referee per each of the main ship subsystems offices belonging to the operations department (e.g. the responsible for the engine equipment) is integrated within the project management team. The figures directly report to the Lead Project Engineer, in a so-called strong matrix configuration. Moreover, they are named as Work Package Managers (WPM) since they are responsible also for the achievement of the economic goal of their technical office. As for the other projects, these figures are still maintaining the interfaces and in charge of coordinating the human resources with the related technical office (or, accordingly, the design network) but they are not shared among more than one project.

> "maybe one might think that it introduces an inefficiency on the use of the resource, […] but the Work Package Manager can follow the commercial aspect towards suppliers and therefore participate in meetings with the purchasing department and our purchasing coordinator with the various suppliers, can participate directly and ensure that the technical alignment activity is carried out more efficiently [..] many times it is an activity that the engineering sees as a lower priority than the development of the project documentation, and therefore having a dedicated work package manager ensures that it is done on time and done well, and is done in time for the issuing of the order that is needed for the program to ensure the arrival of the material" (APM)

Focusing on the organisational learning, the team is experiencing a more effective communication and a better control of the ongoing activities. Having the key technical referees within the same team (and the same room) allows for face-to-face contacts and therefore a more immediate communication, a better control of the ongoing activities and an integration of the design management, leading to fewer changes throughout the project. Their technical experience and their presence throughout the overall project implementation is ensuring the emergence of proactive behaviours towards the alignment of the design and production goals, and the accumulation of the experience in terms of avoiding changes (and deviations), with a higher attention, speed and achievement of quality. Moreover, the weekly (and sometimes daily) meetings that are organised, with the immediate involvement of all the key roles, allow for

> "a more fluid process, you meet around a table and solve the problem in 5 minutes or define the actions of how to solve the problem, […] in my opinion, also with the commission and quality engineer, this is innovative, as now we are developing a tool to estimate the impact that all these changes will have in production and therefore we are trying to integrate all this part of the management of the upstream changes with the engineering, with the effect that we will have the production downstream trying to prioritise and have a complete coverage of the changes that are more impacting on the ship under construction […] so that we have the least possible impact on the project costs, it will certainly be an improvement that will lead to an improvement in the overall performance of company procedures" (CC1)

The proactive and more frequent interactions among managerial and technical members are also enabling a better deepening and efficacy in the management of the project implementation programme (thanks to tools and knowledge sharing), and mechanisms of trust that go beyond the normal relations among colleagues belonging to the same company. The project management team experienced the opportunity to intercept and address in advance the inconsistencies and the possible improvements before entering the production phase, leading to saving extra costs and changes once the blocks of the ship were already pre-fabricated. While these were expected as premises for the new configuration of the strong matrix team, the major initiatives have been introduced thanks to the collaboration, the creativity and the emergence from the bottom, with the achievement of even better benefits. For example, the analysis of the parameters and drivers for the control of the cost and quantities was already present but slowed down and more difficult, due to the distances, intended both as physical and in terms of expertise. The refinement of this analysis and the subsequent introduction upstream changes will be extended to all business processes to improve the overall performance in terms of speed, accuracy and quality. Another important opportunity for the creation of new knowledge is the consolidation of roles that are already present in some projects, as accordingly required by the customer, but not completely dedicated to the related project. The integration of the tools for the tracing and prioritisation of the requested changes, the related problems and the viable solutions will then allow a more fluid process and a better reaction – and proactive behaviour. Moreover, the better alignment between the design, production and purchasing phases thanks to the more frequent interactions demonstrated to be the base for the further trust between the team members and a more in-depth analysis of the engineering process from the technical point of view (i.e. management of the changes to the design), the programme (by better understanding the progress) and the costs (i.e. the variations).

The practice of adopting face-to-face meetings and daily interactions has been extended to the management team and the network of architects employed by the shipowner, as the contractual programme now represents the key benchmark for the delay in the deliverables. Specifically, the knowledge of the shipbuilder on the construction constraints is now extended to the stakeholders as a leverage to become aware of the consequences and impacts on the project development for the ship delivery. The customer is new both for Fincantieri and the market, as it is a multi-business company that only recently entered the business of cruise ships. The less expertise in the shipbuilding implies the need to train the customer but at the same time the decision-making process is more flexible as it is less determined by the customer. This is supported also by the employment of personnel from the cruise market. Being at the beginning of the production phase, this approach is already resulting in benefits in terms of impacts of the requested changes and monitoring of the overall process.

The customer newness, the timing and the stronger linkages within the project management team have been the levers for a significative transfer of knowledge from the previous projects for each of the key roles and the technical referees. Previous experiences were judged as the fundamental base to develop the new roles of the Work Package managers and the cross visions between design and production phases, and purchasing and cost control, overcoming the "cultural gap" due to the different goals and perspectives as mentioned in paragraph 4.3.2. This experience has still not been codified in a formal procedure or guidelines to be shared, rather

> "I think it is appropriate now to manage the project by developing these innovations because only at the end of the project we will check if these innovations have actually brought a benefit […] beyond what our company procedures say, at the end of the project we will make a sum of what we did, and we will transfer it […] I mean it is normal practice among all the teams" (PM1)

> "with the other controllers we meet to share both problems and methods… if you already know who to ask, who has already developed or otherwise is carrying it out ... you have the references, the knowledge is distributed enough quickly" (CC1)

Table 4.5 summarises the dimensions of project complexity and the main mechanisms of organisational learning (at project management team level) within Project 1.

Table 4.5 – Complexity and organisational learning in Project 1 (Music cruise ship)

COMPLEXITY DIMENSIONS		
Diversity		New professional roles and responsibilities Ship size
Interdependency		Better interactions between design and production roles Interactions with the architects employed by the shipowner Alignment on project goals Shipyards capacity requirements
Dynamicity		Evolving team structure Innovative technologies (e.g. engine) introduced during implementation Flexible decision-making due to less customer expertise in cruise ships construction
Uncertainty		New customer, new entrant within the cruise market Creativity Prototype (technological newness)
ORGANISATIONAL LEARNING		
Processes	**Experience accumulation**	Face-to-face communication within the team and with the customer Training of the customer Shared awareness of the impacts of the changes on final delivery Trust mechanisms thanks to better and more frequent knowledge sharing
	Knowledge acquisition	Expertise of the technical referees now belonging to the team Introduction of innovative technologies for cruise ships from other products
	Knowledge codification	Contractual programme as a base for the relationship with the stakeholders Systematic review of project plan in an innovative tool for changes monitoring
Project constraints		Awareness of the shipowner on construction constraints Saturation of shipyard capacity requires rigorousness in respecting the deadlines Efficacy thanks to interaction and alignment between roles
Knowledge communities		System integration with multiple interfaces Overcome the "cultural gap" between the design and production phases Consolidation of roles become key for the fluidity of the overall process

4.4.2 Project 2: Skyline cruise ship

The project comprises the delivery of the second sister ship, whose platform is in common with the one of a prototype ship that was implemented in a period of crisis for the cruise ship market. The previous project was delivered to the shipowner with a lower price than expected, therefore much effort was dedicated to limit the costs and assign priority to the parts of the ship judged as essential, i.e. the functionality, the efficiency in the management of the same ship, the compliance with comfort requirements. The customer is one of the historical ones for Fincantieri, and it has a string expertise in the cruise ship market, gained throughout the years.

Despite the advantages of the economies of scale due to the common platform, the delivery of a prototype ship during the economic crisis with a significative cost avoidance resulted in a series of details to be finalised that are becoming new challenges for this project. The team is experiencing a high variety in the flux of information to be managed with the different stakeholders, adding to the ambiguity due to the missing evidence of previous changes and experience. The new product has been designed with an extremely high-level quality comfort, a payload offering a wide range of onboard entertainments and with the biggest installations among the ships in the ongoing portfolio. This resulted in a higher in dynamicity, with important interventions that in many times were transformed in new solutions to be studied and developed. From the one side, the project manager has to accommodate the changes required by the customer that derives from the customers experience. From the other side, the purchasing orders have to be reconsidered with the new prices after the crisis, with a need to adapt them to the new market dynamics. This element has a strong impact also on the relationships with the suppliers, as

> "we made the decision to take this ship during the crisis with a particularly aggressive price, hoping to implement actions in order to reduce costs in relation to these challenging prices, […] we asked the same approach from our suppliers, so we also gave them a lower price to respect this continuity in a back-to-back logic. […] Nowadays the market is different and there is a further difficulty in managing these ships because the economic values are still referred to the years of the crisis […], obviously every shift with respect to what is expected becomes a problem because it is an economic request, because they claim not to be able to stay inside the costs and therefore any excuse becomes a claim of recognition" (FPC2)

Moreover, some of the project team members changed between the two projects, therefore losing the reference for the technical knowledge on the platform. Another important change is the shipyard itself, with the related technical office that develops the coordination of the building teams from the sharing of the drawings. These significant changes required a higher number of focused meetings with the experts for the information collection and definition of guidelines for the new shipyard and the overall project.

The customer is judged strategic as Fincantieri developed for it most of the prototypes and the key projects in recent years. The first vessel delivered within the contract has been defined among the flagships for the company, with a length overcoming the 300 meters. This new ship is also adding a significative technological content, as it is equipped with the most modern safety systems according to the latest navigation regulations and features the most advanced technologies for energy saving and efficiency, for meeting the strictest environmental regulations. Moreover, the platform adopted is the one in common with Project 7, described in the following.

Focusing on the organisational learning, the team is experiencing the difficulties linked to the inheritance from the previous project within the same contract and the change into the team members, the shipyard and the subsequent decision-making process.

> "the project itself motivates you because you literally have a project, but then sometimes the context demotivates, because you can do a series of reasoning on the project , but if then the context is not consistent with the objectives of the project, it also becomes difficult to be managed ... the motivation lies in continuing to pursue the objectives of the contract given the context in which we find ourselves" (PM2)

At the time of the study, the project is in the implementation phase of the interior fittings. The team members are dealing with the backlog of design work inherited corresponding to the missing details of the previous project, where the implementation of the essential parts and not the tracing of the changes was privileged. The extra workload is integrated with the feedbacks from the marketing department and the customer experience, even if the most important changes regard the technical systems and not the payload (directly experienced from the customers that are now travelling on the first ship). Moreover, the inclusion of new technical referees, starting from the LPE, results in fewer opportunities to leverage on the knowledge created in the previous project. This required the organisation of dedicated meetings with specialists in order to redefine the problem, collect the information and identify new guidelines to define the modes and terms to be held towards the owner that the shipyard is required to keep in the engineering and implementation phase.

Basing on this lesson learned, the managerial roles are updating specific management tools to trace the changes, both from the purchases (e.g. variations in suppliers' deliveries) and the production (e.g. variations in the cost structures) point of view. These support the interested parts, such as the purchasing coordinator of Project 7, in having a direct, real-time and complete information and is in charge of approving the following changes to its project.

Table 4.6 summarises the dimensions of project complexity and the main mechanisms of organisational learning (at project management team level) within Project 2.

Table 4.6 – Complexity and organisational learning in Project 2 (Skyline cruise ship)

COMPLEXITY DIMENSIONS	
Diversity	Ship size Number and type of subsystems to be reviewed Amount of different information
Interdependency	Platform in common with ships of the contract and other brands Frequent interfaces with the customer Outsourcing of the production of a section in a foreign shipyard Synergies with the team involved in the other sister ship Backlog of the design work from the prototype ship
Dynamicity	Decision-making process with consolidated customer Change of project team members (technical) Change of the shipyard (with respect to the prototype) Changes required by the shipowner Reconfiguration of purchasing orders
Uncertainty	New requirements from the change of the shipyard Ambiguity in managing the flux of information

ORGANISATIONAL LEARNING		
Processes	**Experience accumulation**	Economies of repetition for the platform layout Focused meeting to collect information needed
	Knowledge acquisition	Feedbacks from marketing and customer experience Inheritance from the prototype ship
	Knowledge codification	Guidelines for the shipyard Review of ship specific design sheets Management tools to trace the changes
Project constraints		Higher quality requirements than the prototype ship Binding of ship design specifications Knowledge transfer between different production sites
Knowledge communities		Involvement of experts for the technical parts

4.4.3 Project 3: Northern cruise ship

At the time of the study, this project is in the first phases of the development, with the drafting of the general plan and the so-called "zero point" documents, where the scope of the supply is defined, and the functional design officially starts. For this reason, it has offered an important setting for studying especially the learning process of knowledge development with a higher level of uncertainty. Moreover, this project has some peculiar aspects. For example, the customer is new but not completely unknown, as Fincantieri is already working with another company of the same group, and the decision-making process is different. In this case, the customer is th holding itself, who commissioned the construction of four new cruise ships, with tight delivery dates (one per year). Despite the ship is a prototype one, the platform includes technological solutions already implemented for others. Adding to this, the priority of the prototype design for the shipowner is energy efficiency, with the aim of optimising fuel consumption and reducing the impact on the environment to meet the highest environmental standards worldwide, together with the introduction of meaningful innovation that distinguish the brand legacy. In this sense, the project integrates elements of novelty and opportunities of leveraging on economies of knowledge for the shipbuilder. Therefore, the team and the overall organisational process were structured in an innovative way.

The organisational configuration introduced in Project 1 has been adopted also for the team of this project, with some major changes. These were introduced after the evaluation of the fact that having the references of the technical offices introduced into the project management team, the chief of the engineering office risks to lose vision for a single project, with the direct report to the project management team. Therefore, the innovation concerns a functional report, where the functional references report hierarchically to the project management team but have a functional recourse to the chiefs of the engineering offices. Facing project complexity requires indeed the use of multiple interfaces with many offices, such as informal meetings and presentations. These were organised basing on the definition of common, low-level but also challenging objectives such as the strong reduction of the lead time. This is resulting in a better communication with the technical offices (i.e. the design department and the shipyards), especially in the shift between the key phases of the production engineering. Moreover, the project management team includes diverse but well-chosen professional profiles. The managerial roles show different levels of experience and knowledge, offering more opportunities to investigate the arising issues from different points of view and allowing a more positive attitude towards the introduction of improvements.

> "there is a good climate both in expressing difficulty in addressing certain issues and in helping to solve them, so I consider it very positive, so there is a good climate. This in my opinion definitely helps the resolution to the problems because if you fix what I had to do and you had to do, it becomes a very bureaucratic thing, this certainly does not help the development of the activity or in any case the management of the problems that surely there are and there will be. We also have the help of several younger people, let's say junior, who somehow feel that there is an open climate and therefore they are integrating too, […] I think it will help a lot to the development of the project, a positive atmosphere and openness in relationships, it helps to solve these things earlier in the face of different issues" (PL1)

Being in the first phases of development of a completely new prototype ship, the team is deepening the analysis on the overall process in order to gain a systemic view before implementing it in a step-by-step logic. The review of the previous projects and the competitors' practices within the design phase allowed to identify the most important deadlines and the definition of the critical activities (such as the installations that have a major impact on the overall design of the ship in terms of dimensions and functioning). This resulted in the anticipation of the starting time and a deepening of the analysis and discussion of the possible impacts – both from the economic and the programmatic point of view – with all the interested parts. In particular, the involvement of the shipyards earlier than usual in the project lifecycle, and of experts to deepen the analysis, verify and implement the improvements, is enabling to reach challenging lead times.

Focusing on the organisational learning, despite the actual project implementation has not started yet, the team is already promoting ways to codify the created knowledge through the formalisation of best practices and the systematic presentation of the innovative approaches with the other project management teams and the functional departments involved in the implementation of prototype ships. The team is mainly benefiting from the experience accumulation, as they are acquiring awareness from the analyses carried out, especially in terms of simplifying the major common procedures form one side, and capitalising the best practices adopted for facing specific challenges and finding specific solutions. This was reached thanks to the good team climate enabling the try-and-learn and the alignment on objectives formalised together, further extended to the referees of the design and purchases department.

Table 4.7 summarises the dimensions of project complexity and the main mechanisms of organisational learning (at project management team level) within Project 3.

Table 4.7 – Complexity and organisational learning in Project 3 (Northern cruise ship)

Complexity Dimensions	
Diversity	Professional profiles of team members Number of details to consider in the analysis of the key processes Elements to be considered to respond to brand's requirements
Interdependency	Strong ties between team members Multiple interfaces with experts and other departments Linkages between process, organisation and tools Interfaces with design and purchases department
Dynamicity	Decision-making to anticipating critical activities Low-level, challenging objectives
Uncertainty	First phases of functional design Introduction of innovation (technological and organisational)

Organisational Learning		
Processes	**Experience accumulation**	Support in problem-solving Team climate enabling try-and-learn Awareness of impacts pf processes from deeper analyses
	Knowledge acquisition	Imitation of competitors Previous experiences from higher professional seniorities
	Knowledge codification	Standard procedure for design phases in prototype ships Formalisation of best practices Systematic presentations of the innovative approaches
Project constraints		Shipyards priorities Time to introduce improvements Challenging lead times
Knowledge communities		Sharing of the different professional experiences of the members Better communication between the technical offices

4.4.4 Project 4: Panoramic cruise ship

This project consists of a ship which is a particularly innovative prototype, especially in terms of layout and size. It is the largest cruise ship ever built by Fincantieri at the time of the study, and one of the largest worldwide. The layout is new for the cruise market as it incorporates a number of unique design elements, such as the configuration of the external bridges and stairs towers, and at the same time guarantees an increase in performance, with a more balanced weight on the hull and a reduction of the non-revenue spaces. It is new also for the building process in Fincantieri, as it partially derives from the previous ships of the customer's fleet, which were realised by another shipbuilder. Moreover, the customer is new to the type of project (i.e. a cruise ship) within the company's portfolio. Specifically, the shipowner was already a customer of another business unit (i.e. the one dedicated to refitting services), while it was the direct customer for the cruise ships of a competitor of Fincantieri. This required to build the design basing on a ship realised by another competitor (through reverse engineering) and the establishment of a new relationship and subsequent decision-making process. All these elements were significative for the overall project management process, but they had also an impact on the interfaces between the project management teams and the design and purchasing departments, as it required new standards for the drawings, cost structures and purchasing orders.

Despite the elements of novelty increase the dimension of uncertainty, the organisational structure of the new customer allows a better and simplified decision-making process, as direct channels for communication are privileged.

> "the positive thing about this project, especially for us that are directly involved, is that it is a new customer and employs very young people, so we we created a relationship that I personally had not with the other shipowners before. […] Our project manager talks directly with the managing director and the president. Accordingly, we have more direct contacts with the client because they also need us more than expected, we did not know each other and now we are their main interlocutor." (PC)

This major flexibility enables also to better deal with the so-called *owner supply*, i.e. a portion of the budgeted revenues that are reserved for the customer and its choices in terms of sub supplies and other parts that have subsequently to be managed by the project management team. While Fincantieri is already used to this practice, the amount is quite relevant and several interfaces between the subsystems must be taken into account. The elevate request for flexibility resulted in the need to allocate the production of part of the blocks of the ship to more than one shipyard, resulting in a further complexity of interconnections and dynamicity, especially as regards the setting of deadlines to complete everything on time. The customer itself, indeed, was directly involvement in the choices linked to the allocation of the production in the foreign (or the other Italian) shipyards as the company had a major concern on the unique design elements and the brand reputation. This resulted in the re-allocation of the production when the overall process was already started, with severe impacts on the pace of the project. Overall, as described above, the project was characterised by numerous disruptions, overlapping events and challenging decisions to be taken. We can say it represents one of the most important in the current portfolio, with several best practices to be promptly codified and transferred to the following projects of the same contract and the future ones of the company.

Focusing on organisational learning, the project development is characterised by the prevalence of opportunities for knowledge creation, both from the ongoing experience and acquired from other sources, i.e. the other project management teams, the customer, the information from the platform developed by the competitor, the daily meetings with the functional referees. The organisational configuration of the team is the traditional one, with the managerial roles interfacing with the operations, purchases and design responsible people who are collocated in their respective offices. Nevertheless, the need to review the components – and the related purchasing and production orders for the new codes inherited from the previous platform's drawing – resulted in daily meetings between the project management team, especially the technical part with the Lead Project Engineer, and the technical referees, with a mutual exchange of knowledge mainly based on the ongoing experience and the problems to be solved. Moreover, the team created and codified specific transactions on the enterprise resource planning system in order to trace all the transactions with the new codes supplied and stocked, beyond the standardised procedures to trace the changes in the project development.

At the time of the study, the project is close to the launch phase. The previous year there was a severe crisis on the engineering part and a series of interventions were studied, yielding to positive results that are being capitalised in the upcoming months. For example, the problems caused by one of the suppliers, being the exclusive one of a key technical installation, were overcome by internalising the production of that assembly. Another key supplier went bankrupt during the project lifecycle, requiring the search for and the establishment of the relationship with a new one. The team is then trying to codify the experience gained in facing these problems in procedures that don't want to be drawed towards uniformity, rather privileging the bottom-up initiatives of teams involved in the upcoming projects.

> "there is a general willingness to standardise, but then I noticed that a lot depends on the team and how it is composed, especially there is a huge diversity between each project manager based on their experience: there are the project managers who attach importance to the technical part, the ones who claim it is more necessary the economic analysis, who wants to enter more in the relationship with the client…" (FPC2)

Moreover, the team is conscious each project should customise the possible procedure according to the level of involvement of other shipyards, as for example in Project 7, or the organisational setting, such as Project 3 that directly involves the technical and operational referees within the team. Therefore, they are doing a further effort towards integration by avoiding standardisation.

Table 4.8 summarises the dimensions of project complexity and the main mechanisms of organisational learning (at project management team level) within Project 4.

Table 4.8 – Complexity and organisational learning in Project 4 (Panoramic cruise ship)

COMPLEXITY DIMENSIONS		
Diversity		Ship layout and size Higher number of stakeholders due to higher amount of *owner supplies*
Interdependency		Reverse engineering Customer requirements result in more interfaces with the operations department Higher number of interfaces between subsystems (due to several supplies) Externalisation of part of the production to different shipyards
Dynamicity		High percentage of *owner supplies*
Uncertainty		New position of the customer within the portfolio with specific requirements Elements of novelty: ship design, customer, supplies, building process Ambiguity and need to prevent new codes allocation
ORGANISATIONAL LEARNING		
Processes	**Experience accumulation**	Daily meetings with operations functions Informal exchanges with other teams Communication and decision-making process with the customer
	Knowledge acquisition	Customer of the other business unit of Fincantieri Reengineering from a ship realised by a competitor Informative tools
	Knowledge codification	Capitalisation of the interventions on the production engineering Specific transactions on the enterprise resource planning system
Project constraints		New and specific requirements with impact on the quality Flexibility for owner supplies Multi production sites
Knowledge communities		Knowledge sharing with the customer Problem-solving attitude in daily meetings between departments Integration to avoid standardisation

4.4.5 Project 5: Queen cruise ship

The ship that will be delivered with this project is part of a fruitful, long-term contract with one of the historical brands in the cruise ships market. At the time of the study, the project has just passed the steel cutting phase. Being in the first phases after the contract signature, the project management team has to organise several meetings with the shipowner team in order to configure a product that has to be innovative and at the same time not introducing too many advancements in order not to outdate the actual fleet of the shipowner. The vessel is a sister ship, and the platform originates from the largest ship ever realised in Fincantieri before the one currently being implemented in Project 4. It is included in one of the most successful and long-term contract with a shipowner, revealing a strong capability of the shipbuilder to satisfy the requirements and build on the knowledge acquired throughout the relationship.

Even if well-known and part of one of the most consolidated groups in the cruises market, the shipowner is quite eclectic. Specifically, the willingness of the customer is that the ship represents a new technological benchmark in Europe and worldwide for its innovative layout, the outstanding performances and the high-level quality of a state-of-the-art technological content. Dealing with the requirements of redundancy and changes in the design with a strong impact on the final layout of the ship results in a challenging decision-making process. One of the main decision was the allocation of part of the works for the construction of a bow section in a secondary shipyard, to be then transported by sea and assembled to the rest of the unit in the main shipyard. The entity of the workload planned to build all the parts of the ship is substantial, as it corresponds to the full occupancy of both the shipyards, therefore requiring a subsequent detailed planning of the most critical assembly and final construction phases.

The condition of building a sister ship, whose design derives for the prototype one but needs substantial changes to be original, the size and the special requests of the customer make the diversity and the dynamicity the dominant components of complexity. There is the need to re-design all the key installations and their interfaces with the new elements of the payload introduced by the customer. Moreover, the layout is characterised by a redundancy of all the technical systems, aimed to make the ship always functioning even in case of disruption or emergency. The high dynamicity mainly results from the prominent level of change orders from the customer, who also takes into deep consideration the changes in the final market. These include in particular the strict compliance to regulations, such as the ones regarding the safety measures and the public health in the USA, that are not always known in detail and can have an even more significative impact on the overall design of the ship. This results in a more articulate process of change management, as

> "the change always represents a complication, it is always a disruption that is included the ship that you must deliver the same day and in a very short time, because even if the owner is waiting four to five months the value of what is changing, this value actually becomes much more great because obviously time has passed and he is not paying you, he asked you the request six months ago… therefore being able to quickly take all the areas that are involved in the change and to value them properly is part of the complication of the role, together with the coexistence with the other teams" (CC1)

The high dynamicity of this project, even if it aims to the deliver a sister ship, is mainly faced by the strong technical background, the consolidated knowledge of the platform and the ability in recognising and sense the impacts of the customer changes on the final product.

Indeed, the main process characterising the organisational learning within this project is the acquisition of knowledge. This is mainly linked to the fact that this is the seventh vessel realised within the same contract with one of the historical customers of Fincantieri. From the technical point of view, the modularity in the workshop activities was introduced from the previous ship, and basing on the previous experience, there have been created dedicated offices (groups of experts) to assist the production, separately but in strong connection with the office dedicated to timings and methods monitoring, in order to leverage the possible synergies. This is true also in connection with the other project management teams that are involved in the ongoing projects, and with the resolution of the potential conflicts between the shipyards, for which the team promoted the sharing of common objectives and a common sense-making of the product from the technical point of view through the intermediation of these offices.

Finally, the specific and original requests of the customer require a systematisation of meetings and personal relationship with the shipowner, which also enable an important acquisition of knowledge. This also allows to simplify the decision-making process and easily actuate the requests and the subsequent activities in a faster way.

> "As a team, you are able to respond to different needs in a cross-disciplinary way, but it is also changing the demand from the final markets etc. and to be able to process the demand more quickly and more easily… this, in my opinion, is a good way for you to go" (LPE)

Table 4.9 summarises the dimensions of project complexity and the main mechanisms of organisational learning (at project management team level) within Project 5.

Table 4.9 – Complexity and organisational learning in Project 5 (Queen cruise ship)

COMPLEXITY DIMENSIONS		
Diversity		Ship size Redundancy of technical systems Differences in the two shipyards where the production take place Workload and shipyard occupation
Interdependency		Substantial portion of engineering linked to the prototype ship Interfaces with the technical offices
Dynamicity		"Stratified" and articulated decision-making process Prominent level of change orders Pace of improvements Changes in the final market Innovations for the energy saving
Uncertainty		Historical but eclectic brand Economic issues when trying to lower prices
ORGANISATIONAL LEARNING		
Processes	**Experience accumulation**	Important contractual phase Technical elements
	Knowledge acquisition	Modularity in the workshop activities from the previous ship Main technical background
	Knowledge codification	Systematic tracking of meetings minutes Creation of a tool for the warnings
Project constraints		Long-term contract
Knowledge communities		Shared sense-making Consolidated background for overcoming potential conflicts with shipyards Creation of groups of experts for the assistance during the production

4.4.6 Project 6: Inspiration cruise ship

The ship realised for this project differs from the majority of the products constructed from Fincantieri as it is a small-medium size ship belonging to the luxury segment. Even if the project is aimed to build a sister ship, starting form a common platform, the layout and the level of services offered within the ship require a higher attention towards the target quality and the overall implementation process. Indeed, the ship was designed, built and equipped in order to enhance the on-board experience, satisfying extremely high level of comfort, service and quality offered to passengers, and at the same time to prevent air and water pollution with the recognition of important prizes assigned on the basis of the noise levels measured on the ship. In addition to the prototype one, the new ship must also satisfy the highest regulation in terms of complete functioning and safe return to port in case of emergency. From the side of the shipbuilder, the related implementation process implies a strong attention to the definition of the materials, the mock-up of the cabins, the layout of the payload, and overall the management if all the over-standard items.

To fulfil all these requirements, a principal element of complexity has been the disposal and the coordination of the redundant installations – necessary to be compliant with the regulation for the safe return to port – with the already existing ones, together with the payload area, in a reduced space if compared with the bigger ships. Moreover, the customer is requiring a prominent of change orders, that are estimated to have a bigger impact if compared to other projects (such as Project 5) as the unitary price of each item is much higher in respect to the surface of the vessel. Adding to the change, the level of *owner supplies* is prominent, as in Project 4, but in this case, they are mainly motivated by the fact that the customer has less experience in shipbuilding, with a smaller fleet. The challenging requirements caused a saturation of the available capacity of the usual subcontractors, with the need of introducing new suppliers within the design network. This resulted in a higher need, costs and time dedicated to integration, as the systems adopted by the new subcontractors were mainly new for Fincantieri and the coordination was influenced by the cultural distance and the use of different informative tools in support of the executive engineering. Due to the size of the company, the integration process requires much more than the time span for the delivery of a project:

> "leaving the fence of our suppliers to look into a new world made us understand it is not so simple in reality for a complex company like ours and it is not feasible within six months, the process of integration of a new one company or a new system in a large and complex company like our last years without doubts, […] something like the language, especially in the technical field, becomes apparently trivial but becomes fundamental, with the overall issue of systems integration, coding of documents, software systems, work phases, … they seem trivial problems but it was quite challenging" (PL2)

Aiming to solve the problems of coordination and resistance to change, procedures for project monitoring and optimisation of the integration between interfaces have been promoted. The competences acquired through this experience have been employed by part of the managerial team in other change management initiatives across projects, specifically the one aimed at identifying areas of intervention, standardisation and optimisation of the planning process of projects through the development and customisation of a common informative tool for project planning.

Two fundamental mechanisms of organisational learning in this project were the side-to-side support to the shipowner and the daily presence of part of the managerial teams in the shipyard, resulting in the systematisation of the interfaces with the shipyard personnel. Firstly, the specific requests of the customer and the fact of operating in a market with top standards in terms of ship performance represented an important opportunity of "growing together" for both the owner and the builder of the final product. Secondly, the daily interaction of the project management team with the one of operations, directly in the production site, resulted in a significative improvement of the relationship among the departments, by overcoming the conflicts in terms of different objectives (the fulfilment of the project constraints from one side, the saturation and optimisation of the shipyard capacity form the other), in facilitating the flux of information and in fostering the cross-fertilisation of competences among managerial and operational roles (e,g. the planner acquired knowledge in terms of production control).

> "when you are in the condition that you are responsible for certain results, in this case the project manager and the project management team, and you realise you do not have the levers, even hierarchical levers, to govern the processes… then you have to use other approaches, because if I were the manager and I had the goal of delivering the ship only because I am the manager it is not enough that I raise the phone and I say what you must do and must not. […] You are the project manager, if you want to bring home the results you have to use other approaches, be very proactive, much more effective and this is much more expensive, in terms of energy, … […]" (PL2)

> "the procedures must be, in my opinion, rigid and structured, however, because they should always give you the direction to which you should tend, then in the reality you are also required to find other ways, it is the initiatives from the bottom that help, and this is one of them. […] Now each team are going always more often in the shipyard" (FPC1)

Table 4.10 summarises the dimensions of project complexity and the main mechanisms of organisational learning (at project management team level) within Project 6.

Table 4.10 – Complexity and organisational learning in Project 6 (Inspiration cruise ship)

Complexity Dimensions		
Diversity		Ship size (small) Higher level of customisation (variety of subsystems) Different informative tools for executive engineering
Interdependency		Higher integration between ship subsystems Strict interfaces between planned phases Coordination with the redundant installations
Dynamicity		Introduction of innovations for comfort and energy saving Prominent level of change orders and *owner supplies*
Uncertainty		New design subcontractors within the network Cultural distances with the foreign shipyard and subcontractors New customer introducing not feasible requests Ambiguity in the definition of the standards Resistance to change by operators
Organisational Learning		
Processes	**Experience accumulation**	Procedures for project monitoring Activities for the detailed implementation of the layout Side-to-side support to the customer Daily, side-to-side work with the shipyard
	Knowledge acquisition	New ways of working for the functional design from the prototype ship Guidelines to be customised for the planning and control
	Knowledge codification	Systematisation of the interfaces with the shipyard personnel Contribution in the structuring of the professional career paths Contribution to development of the common informative tool for project planning
Project constraints		Important level of quality (luxury segment) Balance between qualitative standards and compliance with international rules Higher costs than budget due to the need for new subcontractors
Knowledge communities		Cross-fertilisation of competences among managerial and operational roles Integration and coordination among systems (technical tools and departments)

4.4.7 Project 7: Eastern cruise ship

This project comprises a vessel which was specifically designed for the Chinese market. It is part of an agreement with one of the main Fincantieri customers, to build four new ships in a little time. In particular, the project consists of the delivery of the first out of two new ships for the brand which operates in the Asian countries. The customer focuses on specific markets and aims to significantly build the Chinese cruise market, being expected to become the second largest in the world at the end of the decade. The ship features an innovative Italian style design, requiring the involvement of mainly Italian interior designer contractors. Indeed, the cruises offered by the brand are already known in China as "Italy at Sea", offering to local consumers a real Italian-style holiday based on food, hospitality and entertainment with a high level of quality.

Focusing on the product structure, the design is derived from the ship designed for another customer, of which this is the first sister-ship. The change of brand had major implications on the interfaces between the payload area and the functional structure. While the platform, which includes the hull and the basic technical systems, is in common with the prototype delivered for the other customer, the required customisations mainly concern the addition of cabins, the reduction of the open public rooms and foremost the change of the funnel, which is the symbol of this brand. The modifies to the layout of the payload area result from the changes in the requirements of the final market, i.e. the Asiatic one. The platform was instead maintained as it was engineered for the previous customer, in line with the features of the size (gross tons) and the capacity of the ship (number of passengers).

The production is still in the phase of workshop at the time of the study. In the meanwhile, the design of the sister ship – the second with this brand – has already started, with some changes in the dynamics in the decision-making process and the opportunity of leveraging on possible synergies with it. Furthermore, a substantial section of the vessel (almost one third) is completely built in a foreign shipyard, belonging to a subsidiary company. This vessel is among the first ones partially manufactured in a foreign shipyard, moreover, the section is the biggest one among the ones being outsourced. This has several implications on the coordination in the production phase, as the harmonisation between the two shipyards is still uncompleted and there is a low level of interdependency. While the standard WBS cruise ship is shared and consolidated among the Italian shipyards, the variances in the requirements and contingencies of the foreign shipyards imply additional degrees of uncertainty and unclarity. The difficulties already present in the so-called "grey zones", where the tasks and the definition of responsibilities among different actors are not always clear, are even worsened by the differences in the language and in the organisation of the workload.

As regards the relationship with the customer, this project is in line with the willingness to consolidate the strategic partnership with the customer. For this reason, the decision-making process is quite challenging. The project team was originally born to manage the projects with two different shipowners. Due to the decision of structuring a more customer-oriented team, the initial configuration was subdivided into two dedicated teams. Furthermore, the challenging requests from the customer leaded to the creation of a project management team totally focused on the Eastern cruise ship delivery, i.e. the actual one. These organisational changes resulted in a need for further interconnections between the previous and the present team. Usually, the signature of the contract is followed by an initial phase of analyses, quantity checks and evaluation on the possible ways to carry out the activities that are in charge of the team that will manage the construction until the final delivery. The handover between the two teams, when the workshop phase has already started, resulted in some initial difficulties and the need of time and additional information sharing to reach a full understanding of the peculiar processes and specifications, and thus take a full control of the management of the project.

Further deepening the analysis on the knowlegde acquisition, the present team is using the project management practices already consolidated within the company. The cost analysis was inherited from the previous team, while the quantities (such as the steel) varied according to the modifies in the layout of the new ship. A major innovation concerns the outsourced activities to a foreign shipyard. The novelty and the daily contingencies in cooperating with a foreign operative team were faced by the team members with a further effort in reviewing the procedures already established and a try and learn approach.

> "Although we do not always do the same things, we have a norm, a procedure to handle things in a common way… rightly, they have their structure and they handle things in their way, thus even being able to communicate and speak the same language, be sure that the object we are analysing has the same perimeter has a great degree of difficulty and it is a sort of new question mark. It had not been done before and thus we are going with a try and learn approach […] I'm sure it will help in dealing with these issues, as far as we are going to have other sections of ship outsourced. Undoubtedly, we are making a treasure of the experience we are living, to try to deal with it in a more systematic and standardised way in the future" (CC2)

Table 4.11 summarises the dimensions of project complexity and the main mechanisms of organisational learning (at project management team level) within Project 7.

Table 4.11 – Complexity and organisational learning in Project 7(Inspiration cruise ship)

COMPLEXITY DIMENSIONS		
Diversity		Ship layout Foreign shipyard Higher number of suppliers
Interdependency		Changed team Previous multi-client team Building of the sister ship already starting Need to foster information sharing
Dynamicity		Final market dynamics Decision-making process Difficulties in the handover phase
Uncertainty		High level of outsourcing Grey zones, unknowns Absence of established procedures for information sharing with foreign shipyard New brand Cultural distance
ORGANISATIONAL LEARNING		
Processes	**Experience accumulation**	Try and learn Focus on minor orders
	Knowledge acquisition	Recovery from knowledge repositories Internal transfer of information already defined
	Knowledge codification	Formal project reviews Formalisation of functional interfaces
Project constraints		Tracing impacts of minor purchasing orders
Knowledge communities		Definition of roles and responsibilities Technological platform Network with subsidiary employees

4.5 Organisational Learning in a Multi-project Environment

This section outlines the organisational learning processes and main themes in the multi-projects environment, i.e. considering the interfaces and the mechanisms across projects. In Fincantieri the processes and mechanisms for the management, development and dissemination of knowledge are distinguished between the operational and the overall organisational level.

At the operational level, the teams and the project managers organise informal meetings and face-to-face consultations to share changes, problems to be faced or other issues of interest as all the possibly involved parts get informed on a real-time and complete basis. The company has a formal procedure for distributing and sharing the knowledge created within a project, strongly motivated by the top management, but

> "in fact then the informal channel is the most immediate ... these things are not done here because it is written in a procedure, they are done because it is common sense to do them and because there is a project management manager who should have among his tasks, not managing the specific project, should have among his tasks that of developing knowledge, spreading knowledge among the various teams, developing a method, a culture and therefore is naturally requested and is naturally stimulated and it becomes part of the daily work to do this type of activity." (APM)

Each project management team utilises and has the access to a variety of standardised tools such as common WBS and cost structures, product and production engineering, process maps, datasheet in the enterprise resource planning system, previous ship review. While these tools are mainly standardised and common to different teams, the organisational procedures to access the knowledge created (such as the changes and related problems) in other projects are not. When the issues are more specific for a type of project or ongoing situation, it stays at the single project manager. Exchanging knowledge and experiences with other project managers when managing a project with a significant degree of similarity to a completed (or ongoing one) is a consolidated practice of the managerial roles in Fincantieri. Dealing with the complexity and the organising into a multi-project business brings the project management teams to undertake initiatives that are mostly self-activated, as

> "It is quite common transferring from the intervention of the individual to the company knowledge […] there is an existing entity that is the organisation and that entity is to be questioned on these things and must also lead to the formality of, not bureaucratisation, the spread of knowledge, bringing it into the procedures, and make it as corporate assets." (PMC)

At the organisational level, the main innovations that are stimulated from the top management regards mainly the issues across projects, that represent a benefit for all the products and the teams:

> " when you have to deal with important changes of the modus operandi it is clear that it is difficult to be born right here, because we are oriented precisely to the daily product where you are focused what you have to do today, tomorrow, the day after tomorrow… you are not always able to have such a vision so important as to be able to make substantial changes… it is something that normally comes from the practical side as a change on my ship could be a benefit for me, but to be for other products there is the need of a multi-task logic, a more transversal experienced figure that introduces a certain change" (LPE)

Moreover, the ship review is one of the structured documents that represent a key knowledge repository for all the projects. Once each ship is delivered, this complex document collects all the feedbacks, the problems and the changes taken over the project development in order to be re-analysed, discussed and therefore be the base of the lesson-learned for all the ongoing and future projects. Beyond standardised roles and procedures, good and best practices are formally and constantly collected to be included in a common base of knowledge within the organisation. Positive experiences in terms of ways to carry out the planned work and solve the problems are capitalised in evolutive procedures that become part of the company knowledge and core competence – and not only of the single persons.

> "The organisation makes some attempts, sees if these attempts are successful, then it self-organises, it tries to make an experience from the arguments that were made. Then usually there are some more formal moments in which these reasonings are systematised" (FPC2)

There is a prevalence of informal initiatives for codifying and sharing knowledge on specific issues, emerging from the day-to-day management, while the formal reviews are privileged for more common issues. Despite the clear advantages, the informality often resulted in the lack of codification of specific activities, therefore requiring reconstructing the information without opportunities of standardisation and mainly recurring to the personal contacts. These are motivated also by the strong awareness of each member on when and where the knowledge was created and accumulated (on the operational side) and the contextual factors characterising its creation. Once identified the source or the person who has already experience on the issue under investigation, the information can be structured, with a little loss of time, or unstructured, resulting in wasted processes but also in opportunities for innovation. Differently, the formal reviews have been simplified in the last years as it was given much importance and evolved in a bureaucratic procedure that it seen more as an interruption rather a support for the daily work. For knowledge acquisition, the top management of the project management unit collects the feedbacks form the teams and the functional departments (design, purchases, production including all the shipyards) and evaluates possible actions, in order to perform a following executive, top-down transfer of guidelines, according to the specific situation. This take place in meetings where all the interested parts are called to share a series of reflections on the more structured, across-projects level processes such as the tools and procedures for the production programming and the quality management.

Focusing on the aspect of the project lifecycle, both the stability in the project portfolio and the front-end phases enable the teams and the overall project management unit to evaluate possible improvements and change actions. At the beginning of the project and especially in the engineering and production phases, building on common platforms (within the same contract) and common WBS (in multi-projects) allows to reach to reach economies of both learning and scale as

> "a solution that you have already engineered maybe you already know the problems you had, so in the meantime you had the chance to try to solve them … and after these you already have a product that already works, so even when you re-manufacture it you should suppose it's better doing it in a better way, as you know it better – while with a new product there are many unknowns, who is going to actually produce it has to study every detail, every drawing … besides the fact that it is already complex" (CC2)

During the last decade, the project management unit (reporting to the Merchant Ship business unit) launched important studies on organisational and other specific issues in collaboration with external consultants. These were focused on the organisational re-design and the development of integrated models allowing to better address the complexity of their projects and enhance the employees' experiences and day-by-day work. Several recent initiatives enabled to improve the experiences and competencies of the project teams (and functional) members to address specific issues that could become synergic among multiple projects and respond to both customer and internal integration needs. Overall, the company demonstrates a clear willingness to develop tools and practices fostering the creation, sharing and retaining of the acquired knowledge at the organisational level.

> "Due to the complexity caused by the integration of different solutions, different design disciplines, and active coordination, it is crucial to avoid coordination mistakes that can generate problems and above all higher unplanned costs during the construction phases." (PM2)

An example is the creation of professional clusters, i.e. professional knowledge communities. One of the strengths is the identification of the characteristics of each community basing on the experience accumulation, avoiding the risks of levelling the people into fixed roles. These communities involve a strong attention on the training, the update of the competences of the employees, and the development of professional career paths.

> "From the point of view of the experiences within the company, we have just launched a study on the career paths. I mean, we mapped what should be an ideal path for those who are covering roles or in general second or third levels in the company, from the head of the shipyard, to the project manager, the planner, the Lead Project Engineer, to the purchasing manager, etc. drawing an ideal path that everyone should do to have all the skills to succeed in covering that role. We are relying on the past experiences, those that are shared practices and also what should be an ideal model of path and skills" (PMC)

This map is the base to establish whether the employees covering roles with responsibilities have the entire spectrum of competences and understand what the current patterns and the future possible bifurcations in the professional growth are. Taking into account the day-by-day contingencies linked to the considered person and the available opportunities, the choice on the possible reallocation to the key roles privileges the people with cross-functional experiences, in order to maximize the ability in coordinating and being at the interface with a variety of professionals and stakeholders.

> "we are the support function to all the other functions, so naturally the more experience you have in the company in other roles, the more maybe you can make a contribution – or because you have experienced the same issues, the same problem in previous constructions maybe you can give a positive contribution to the process, but then we are facing the complexity of our projects that is inevitable that there are some problems repeated throughout the various ships, even if, for example, you already faced the some changes to that supply" (PC)

Different professional clusters or families are the entities bearing the knowledge, skills and even uniformity traits for the roles in the PM team. At the same time, they ensure that best practices are shared and disseminated among the various project managers, limiting the risk that everyone works differently. This is supported by the identification of coordinators, external to the PM teams, who are in charge of guaranteeing a level of uniformity and common paths for the professional growth of the persons belonging to the PM teams. These people are identified as primus inter pares, which is not the head of planners or controllers, but they dedicate more frequently to exchange knowledge with the other interfaces (same or other roles), collect the positive or negative elements of the various experiences, organise workshops in which gather these, draw up guidelines. The identification of knowledge communities follows the codification of the role of the project manager and the formalisation of its involvement in a series of issues that were previously under the total supervision of the departments referees.

> "there is a balance always changing over time, by force, due to people, the needs of the context… there isn't a defined recipe that is always fine, there is a recipe for that period but must be always subject to revisions ... so it is a natural change that derives a little from the experience gained that has allowed us to give substance to the concept we had of the project management, and a little also derives from the context that has changed, so the need to make it evolve somehow in short time" (PM2)

Another example is the customisation of tools specifically designed for the planning and programming of projects, in order to provide common interfaces and integrate all the disciplines (i.e. project management, design, production, purchases, supporting processes such as quality monitoring and control) strictly linked to the project lifecycle and related tasks sequencing. Beyond the physical tools, the company promoted the organisation of self-organised teams dedicating part of the time reserved for the operational work to contribute in the identification of the possible synergies and developments.

Table 4.12 summarises the mechanisms of organisational learning in the multi-project environment of Fincantieri, i.e. across projects.

Table 4.12 – Organisational learning in multi-project environment

ORGANISATIONAL LEARNING		
Processes	**Experience accumulation**	Interfaces between operations and project management teams Informal sharing routines between teams Emergence of professional communities, i.e. same roles within the teams Job descriptions
	Knowledge acquisition	Best practices from other business units, e.g. refitting Task force for actions for harmonisation of the shipyards Systematic review of the project processes Personal relationships Dedicated meeting for information transfer among same roles Alignment on common challenges Involvement of team members in change projects
	Knowledge codification	Rules for shipyards coordination Consolidation of common WBS and cost structures Product and production engineering Process maps Datasheet in the enterprise resource planning system Previous ship reviews Tools and not organisational procedures to access problems in other projects
Project constraints		Uniqueness of the projects and the teams vs. repetition Economies of scale Make-or-buy choices Commonalities between projects of the same contract Synergies among shipyards Milestones Not too elevate expertise (specialisation in a discipline) Design and programme system integration
Knowledge communities		Economies of learning Mapping of distributed knowledge Definition of career paths Alignment for creation of internal professional communities Informal networks to favour interactions and information exchange Role of "primus inter pares" for fostering processes and mechanisms for the management, development and dissemination of knowledge

CHAPTER 5. DISCUSSION

5.1 PROJECT COMPLEXITY AND LEARNING WITHIN PROJECTS

The Fincantieri case suggests how organisations, especially the project-based ones, are facing the complexity of their projects with different organisational learning processes.

Cruise ships projects are recognised as being complex mainly because of the high level of complexity of the product, the level of customisation that requires a dedicated project management process, a high number of stakeholders and the goals that the process itself has to achieve by following tight project constraints. These latter are strictly linked to the low marginality, as the design and production of a cruise ship require the supply of several components and subsystems (as turnkey projects) from a wide network of subcontractors, and prolonged periods (i.e. up to three years). Shipbuilding is indeed an engineer-to-order and not a mass production industry, and each shipyard has a prominent level of externalisation, requiring a proper project management process and capability by the shipbuilder's side.

In Fincantieri each project is managed by a project team that is usually customer-oriented. It has a strong focus on the brand of the shipowner, aiming to ensure a long-term relationship with the customer through the same interfaces and approaches, and each project is linked to a contract (which discipline the delivery of more than one ship per customer). The prominent level of customisation and the high customer power result in the need to accept several change orders from the customers and coordinate a huge construction process with several constraints in terms of integration. Conversely, the interfaces of the project management teams are manifold: they are required to deliver a ship on time, on budget and fulfilling quality requirements by dealing with the functions directly involved in the development and construction phases, involving several stakeholders with different objectives. Therefore, the organisational forms, the attitudes and the managerial and organisational practices put in place by the project management teams have several implications for the success of the project delivery.

The analysis of Paragraph 4.3 shows that in general cruise ship projects demonstrate to be complex in terms of diversity, interdependency, dynamicity and uncertainty. These can be identified in the product (cruise ship), in the involved stakeholders, in the organisational practices of the project management team that is in charge of delivering it, and in the project management practices as well.

Focusing on the product, the cruise ships are large constructions with an elevated number of systems and a number of non-naval technologies. The design of each ship is developed basing on a technological platform, which is completely new and created from the scratch if the ship is a prototype one, integrated with the so-called payload area. In addition to the high number and diversity of subsystems, their interfaces and the efforts required to connecting them result in a high interdependency. Therefore, the production process requires prominent levels of coordination and timing. Adding to this, cruise ships construction projects are implemented over long-term horizons and usually in different production sites, with two sections of the same ship constructed at the same time, requiring a multi-site coordination. The dimension of dynamicity is mainly linked to the requests of changes by the customer or the different allocation of the project in the production line from the shipyard point of view.

As regards the stakeholders, these are numerous, vary in terms of organisation and type of relationship to build with and in the subsequent emerging relations and patterns. They act as agents that observe and act on local information only, derived from the other agents to which it is connected (Anderson, 1999), rather than gathering perfect information that would be necessary for utility maximising choices (Mitleton-Kelly and Ramalingam, 2011). Throughout the production cycle, Fincantieri has the role of integrating and coordinating a large number of suppliers based in the shipyard, with a dynamic management of any modification before the final delivery. In the last few months before the due date, the integration and coordination efforts are even amplified with tighter schedules and less time for facing actively the possible problems and the changes. Each shipyard has a strong connection with the satellite activities and the local community where it is based, dealing with important elements of dynamicity (e.g. possible disruptions due to strikes) and uncertainty. The main aspects to be managed are the interfaces with the shipowner and its network of architects and consultants, especially as regards the ship configuration, which often results in a high number of change orders.

Finally, as regards the organisational practices, each project management team is constituted basing on the managerial complexity of the project. Each project management team is led by a project manager and includes the key roles identified as Lead Project Engineer or LPE, purchasing coordinator, project planner and cost controller, guaranteeing a variety in terms of technical and managerial competences, and at the same time tight interconnections within the team. Each role is responsible to interface with the functional referees, dedicating also to overcome possible conflicts in terms of objectives to achieve. Indeed, the project management team is in charge of achieving all the project goals, while the functions are generally focused on single performance indicators, resulting in a further level of uncertainty on the project success. Along the same line, the project management practices are included in a process (i.e. the project management itself) that supports the others throughout the project lifecycle. The overlapping between the phases is relevant and represents another element of complexity as the project is mainly defined during its development (especially during the last phases before the final delivery).

The embedded case study emphasizes that the level of complexity of a cruise ship project take to the emergence of a learning process, especially from the point of view of the organisational role who are responsible for completing it on respect of a set of requirements and in connection with several entities. Specific learning processes can occur often as an unintended outcome of the project activity (DeFillippi and Arthur 2002). The prevalence of complexity dimensions as key contextual variables under study might play a key role in determining the type of learning (Sorenson, 2003). Specifically, the sub-processes of organisational learning studied in the ongoing projects of Fincantieri were the knowledge creation through experience accumulation, the knowledge acquisition and the knowledge codification. Attitudes, tools, practices and outcomes of learning were studied at the light of the project constraints, which showed to both limit and foster the collaborative and learning processes. Moreover, dealing with complexity in the project management practice revealed the creation of the so-called "knowledge communities", where decentralised sub-units develop shared, experience-based knowledge by working close together (Lindkvist, 2005).

The cross-case analysis on the sub-units allows identifying the main dimensions of complexity and the prevalence of specific learning processes according to distinct levels of complexity in the seven projects selected. Table 5.1 shows the summary of the qualitative data per each project, resulting from the qualitative questionnaires administrated to the project management teams of the seven projects and representing a synthesis of the deeper analysis performed in Chapter 4 for each project.

Table 5.1 – Cross-case analysis on project complexity and organisational learning within Projects 1-7

	COMPLEXITY DIMENSIONS					LEARNING PROCESSES			
N.	Diversity	Interdependency	Dynamicity	Uncertainty	*Mean*	Experience accumulation	Knowledge acquisition	Knowledge codification	*Mean*
1	4	5	4	3	*4*	5	3	5	*4,3*
2	3	5	5	4	*4,3*	4	5	5	*4,7*
3	4	5	3	4	*4*	3	4	5	*4*
4	5	4	3	3	*3,8*	3	5	4	*4*
5	3	4	5	4	*4*	3	5	5	*4,3*
6	4	4	5	4	*4,2*	5	4	5	*4,7*
7	3	4	3	5	*3,8*	5	4	3	*4*
Mean	*3,6*	*4,4*	*4,0*	*3,9*	-	*4,0*	*4,3*	*4,6*	

While each value can differ as each project has unique, one-off characteristics that distinguish it from the others (starting from the constitution of the team itself), even if carried out within the same organisation, we can identify similarities and differences per each dimension of analysis.

Focusing on complexity dimensions, their levels and constituent elements, Project 2 and Project 6 show the highest values. The former is strongly conditioned by interdependency and dynamicity. It comprises the delivery of a sister ship, whose platform derives from the one of a prototype ship that was implemented with a lower price than expected. The team members are dealing with the backlog of design work inherited corresponding to the missing details of the previous project, where the implementation of the essential parts and not the tracing of the changes was privileged. Moreover, the project development was affected in terms of dynamicity by the change of some of the project team members (specifically the technical experts), the need to accommodate several change orders from the shipowner, based on its and the customer experience – as it is one of the main players in the cruise ship market – and the main shipyard where the ship is built, with severe impacts on the overall decision-making process. Project 6 shows a high value in all the complexity dimensions. The most relevant one is the dynamicity, due to a higher attention towards the target quality (as it is a ship belonging to the luxury segment), the need to satisfy highest regulations in terms of complete functioning, energy savings and comfort, the prominent level of change orders and *owner supplies* (i.e. the purchases directly decided by the customer, especially in terms of unitary value per size of the ship). Furthermore, the other complexity dimensions play a significant role in determining the overall complexity level as well, in a connected way. Diversity is also linked to the level of customisation in terms of subsystems, interdependency as well results from the interconnections among these and the network of stakeholders. This influence prominently also uncertainty, as it derives from new design subcontractors within the network, cultural distances with the foreign shipyard and subcontractors, new customer introducing not feasible requests, ambiguity in the definition of the standards, resistance to change by the operational departments.

Overall, all the projects show a high complexity (between 3,8 and 4), resulting from the combination of the different dimensions. Project 1 is mainly characterised by interdependency, especially from the organisational point of view, as it presents better interactions between design and production roles, the building of interactions with the architects employed by the shipowner and an alignment on project goals. This also results in a lower level of uncertainty, as the customer and the design novelty are mitigated by the strong connections within the team and with the customer. Focusing on the technical aspects, mainly linked to the production process, the main interconnections are among the ship size and layout and the shipyards capacity requirements. Project 3 as well shows a higher level of interdependency, even if it at the first phases of the development. Indeed, the project inherited the organisational configuration adopted in Project 1 and strengthened the interconnections thanks to the definition of common, low-level but also challenging objectives such as the strong reduction of the lead time. Project 4 is the one showing the highest level of diversity. Indeed, it is characterised by a ship layout and size which presents relevant elements of variety, a higher number of stakeholders due to higher amount of *owner supplies* and the consecutive need to allocate the construction in multiple shipyards. The highest level of dynamicity in Project 5 is due to the multi-level and articulated decision-making process, basing on the outstanding performances required for the ship and the presence of an eclectic customer, the prominent level of change orders, the pace of improvements to be introduced after the strict requirements following the changes in the final market and the standards of innovations for the energy saving. Finally, Project 7 is the one characterised by the highest level of uncertainty, as the teams is dealing with high level of outsourcing to a foreign shipyard, the grey zones and the unknowns in the informative process, the absence of established procedures for information sharing with foreign shipyard, adding to the brand, which is new for Fincantieri, and the cultural distance as the ship will be delivered for the Asian market.

Generally, projects are characterised by higher levels of interdependency and dynamicity rather than uncertainty. This fact can be justified by the actual state of the projects, as they are all ongoing at the time of the study. Most of them is at distinct stages of the design, engineering and production phases. The dimension of interdependency, i.e. the degree and emergence of interactions and interconnections among the elements, is the highest on average. Indeed, all the projects exhibit a value between 4 and 5. Despite each team deals with different customers, shipyards and in general stakeholders, they are all strongly connected and spend much efforts in integrating and coordinating a smaller or bigger network of relationships. Moreover, the product itself is made of subsystems that must be integrated and properly managed throughout the project lifecycle. For example, Project 4 is developing the reverse engineering from a ship designed by a competitor, therefore leveraging on the interconnections with the previous drawings, and is dealing with a high number of interfaces with several supplies and different shipyards to which the production was externalised. The team involved in Project 5 is having mostly interfaces with the technical offices, due to the significative technological content of the ship (e.g. redundancy of technical systems). This latter is present also in Project 6, but the main interconnections are between the planned phases and the ship subsystems, beyond the redundant installations as well. Finally, the dimension of interdependency in Project 7 is mainly in terms of interconnections between multi-teams, as it is strictly linked to the previous configuration of the team and to the building of the following sister ship, which is already starting at the time of the study.

Conversely, the dimension of diversity presents the lowest mean value among the seven projects. This is mainly due to the ship sizes and layouts, the composition of the teams, the use of different practices and tools supporting the project management process, the number and type of information to be considered. All these elements represent a minor driver of complexity in terms of management of the related project as they mainly reflect the experience and the modus operandi of the overall company, which is mainly client-oriented and has a strong expertise in all these variables – a characteristic that is in common with all the projects within the current portfolio. Building on similar considerations, also the dimension of uncertainty is lower than the others.it is mainly due to the newness of the customer (e.g. Project 1 and 7), the newness of part of the stakeholders involved in the design (e.g. Project 6) and purchasing (e.g. Project 4) phases, the introduction of technical or organisational innovations (e.g. Project 1 and 3), the cultural distance (e.g. Project 6 and 7) and ambiguity in the information, the setting of the standards or the presence of unknowns (e.g. Project 2, 4, 6 and 7).

Focusing on organisational learning processes, what immediately emerges is that Project 2 and Project 6 show the highest values (near 5) also for this variable. For what concerns Project 2, this is mainly due to the inheritance of the prototype ship, which resulted in both positive (e.g. commonalities and opportunities for economies of repetition and the feedbacks from the customer experience) and negative (e.g. backlog of the design work, the amount of changes required by the shipowner, the reconfiguration of the production in another shipyard and the purchasing orders) aspects. This resulted in the prevalence of knowledge acquisition, as the team leveraged the previous information and proactively created occasions to collect as many data as possible with focused meeting to collect the information needed from all the stakeholders. Moreover, basing on this lesson learned and the willingness to avoid the problems encountered in reviewing the previous project, the project management team is often codifying the knowledge acquired in new or improved tools. They are updating specific management tools to trace the changes, both from the purchases (e.g. variations in suppliers' deliveries) and the production (e.g. variations in the cost structures) point of view, with also the support of guidelines. These enable the interested parts in having a direct, real-time and complete information and is in charge of approving the following changes to its project. Project 6 shows similar values in all three processes, but differently from Project 2 the experience accumulation is prominent in the knowledge creation process: Indeed, dealing with the high standards and subsequent requests of all the stakeholders involved, resulted in the emerging, from the bottom, of informal procedures for project monitoring, activities for the detailed implementation of the layout, a side-to-side support to the customer and work with the shipyard. The knowledge gained in this way was then promptly systematised into better definition of the interfaces with the shipyard personnel and a twofold contribution in the structuring of the professional career paths and to the development of the common informative tool for project planning, as explained in the following Paragraph 5.2.

Overall, all the projects show a considerable level of all the sub-processes of organisational learning (between 4 and 4,7). Project 1, similarly to Project 6, is mainly characterised by experience accumulation and knowledge codification. The project management team members are leveraging on the high interdependency, mostly at the organisational (i.e. within the same team) and environmental (i.e. with the stakeholders) level through mechanisms such as face-to-face communication within the team and with the customer, training of the customer (being new in the cruises market) with also a shared awareness of the impacts of the changes on final delivery, and trust mechanisms thanks to better and more frequent knowledge sharing. Codification is mainly reached through the formalisation of the contractual programme as a base for the relationship with the stakeholders and the systematic review of project plan in an innovative tool for changes monitoring, to be shared in the future with the overall organisation. Project 3 as well shows a higher level of knowledge codification, helped also by the fact that the project is in the first phases of implementation and the opportunities to build on previous knowledge and the team members expertise to create new or modified tools are more numerous. They are indeed trying to draw standard procedure for design phases in prototype ships and the best practices, in addition to the systematic presentations of the innovative approaches. Project 4 is the only one showing a higher level of knowledge acquisition if compared to the other sub-processes. This is mainly due to the knowledge base inherited from the experience with the customer when it was served by the other business unit of Fincantieri, the need to build the design from the reengineering of a ship realised by a competitor, the available knowledge on the informative tools to be promptly customised according to the high level of *owner supplies*. The high level of both knowledge acquisition and codification in Project 5 is due to the need of configure a product that has to be innovative and at the same time not introducing too many advancements in order not to outdate the actual fleet of the shipowner, one of the historical of Fincantieri and more eclectic in advancing the requests. This resulted in the systematic tracking of meetings minutes and the creation of a tool for the warnings. Finally, Project 7 is the only one characterised by a higher level of experience accumulation if compared to the other sub-processes. This can be connected with the higher uncertainty faced by the team, resulting from the unknown and the cultural distance deriving from the externalisation of part of the production and the layout of the ship (based on a new final market choices). Therefore, the team is creating new knowledge within the project by following a try and learn approach and focusing on the emergence of specific issues such as the minor orders, trying then to evaluate the related impacts in constant reviews. Overall, we can say the main innovation and change management initiatives are mainly developed at the front-end stage. One of the main opportunities for innovation is the organisational redesign (Gann and Salter, 2000; Hobday, 2000), as in Project 1 and 3 with the strong matrix configuration.

Generally, projects are characterised by higher levels of knowledge acquisition and codification. This reveals a positive attitude towards building on the knowledge gained in other projects (e.g. Project 2 and 3), or in other teams (e.g. Project 7), or the information coming from and the competences of the project stakeholders, starting from the functional departments such as the shipyards (e.g. Project 5 and 6), to the customer itself (e.g. Project 2), to the competitors (e.g. Project 3 and 4). Moreover, several mechanisms have been put in place to codify the knowledge created into tools and practices to be shared in the next future with the other teams and the upcoming projects. The single project teams explore their space of possibilities and or alternative strategies to generate a variety of responses under different environmental conditions (Mitleton-Kelly and Ramalingam, 2011). Examples of mechanisms include innovative tools for changes (e.g. Project 2) and minor items (e.g. Project 7) tracing and monitoring (e.g. Project 1), the contribution to the development of the common informative tool (e.g. Project 6), for project planning guidelines for the production stages (e.g. Project 2), the creation of specific transactions on the enterprise resource planning system (e.g. Project 4) and a tool for the warnings (e.g. Project 5), the core contribution in the structuring of the professional career paths (e.g. Project 6) and the functional interfaces (e.g. Project 7).

Finally, all the project management teams show a proactive attitude towards creating (and contributing to the improvement of) knowledge communities, i.e. a practice-based context where decentralised sub-units develop shared, experience-based knowledge by working close together (Lindkvist, 2005). Knowledge communities (professional, but also informal) were created with different mechanisms. Among the main important ones, there are the overcoming of the "cultural gap" between the design and production phases (in terms if objectives) with a better communication as in Project 1, 2 and 6, the consolidation of roles become key for the fluidity of the overall process as in Project 1, the involvement of experts for assistance as in Project 2 and 5, the sharing of the different professional experiences of the team members as in Project 3, in addition to the cross-fertilisation of competences among managerial and operational roles as in Project 6, a better integration and problem-solving attitude as in Project 4 and 6, the building of a shared sense-making as in Project 5, with also a better definition of roles and responsibilities and formalisation of real networks as in Project 7.

An important result is that, on average, a higher level of both interdependency and dynamicity (even more if both present as in Project 2) results in a higher knowledge codification. Beyond the experience of the project management teams, dealing with several interfaces (i.e. customers, functional units, design and production subcontractors) and pace of the projects allows for a better organisational learning process. Higher interdependency requires building on feedback loops and create brainstorming sessions to map the interconnections, reconsidering the challenges to be faced from other projects, as it has been done in Project 2, with a higher number of focused meetings with the experts for the definition of guidelines for the new shipyard and the overall project. Interaction is essential for learning to take place (Mitleton-Kelly and Ramalingam, 2011).

Focusing on the single dimensions, a higher diversity mainly results in the need to acquire knowledge from the external of the project. For example, in Project 4 the high level of innovativeness of the ship required to leverage on the re-engineering (and then the imitation) of the model previously delivered by a competitor, the knowledge from another business unit of the company and other teams as stocked in the common informative tools. The higher dynamicity requires both knowledge acquisition and codification. The acquisition comes mainly from strongly relying on the external sources, and in particular on the previous projects, the previous experiences of the team members and also the competences of the main stakeholders, when properly shared. Indeed, people working in projects use their existing knowledge to help guide their action, but gain understanding of the new type of project by carrying out their specific work in a socially constructed context (Cicmil et al., 2006; Cook and Brown 1999).The codification mainly addresses issues that are specific of the ongoing project at the operational level, as it has been done in Project 6, with the main focus on the integration of the planning and programming with the functions due to the technological content. The tools and practices codified in each project should be then properly reviewed to be shared with the overall organisation.

5.2 PROJECT COMPLEXITY AND LEARNING ACROSS PROJECTS

Focusing on the complexity in a multi-project environment such as a project-based organisation, we took into account in the analysis that the principles of complexity are scale-invariant same from group to organisation (Mitleton-Kelly and Ramalingam, 2011). At the level of the overall organisation, the short-term emphasis on project performance and distributed work practices, which have a direct influence on the ways in which broader organisational initiatives are interpreted, legitimated, modified and incorporated within such a dispersed system of practice. (Bresnen, 2004). Dealing with multiple projects carried out in parallel, the role of system integrator of the company has several implications also on the organisational learning processes that can take from project to project and from the single projects to the overall organisation. Many factors must be taken into account, starting from the guidance that team members participating in the project receive from their organisation, the imitation of the others, and the personal experiences beyond the ongoing project (Leufkens and Noorderhaven, 2011). Therefore, the processes and mechanisms for the management, development and dissemination of knowledge are distinguished between the operational and the overall organisational level.

The project management teams have to face several interfaces at the operational level, mainly due to the conflicts between the temporary organising and the presence of multiple stakeholders. They have to satisfy innovation requirements, which is opposite to the routinisation of the functional departments. Moreover, the case study shows the different focuses and target performance of the different units that results in possible tensions even within the same organisation. Dealing with high dynamicity requires an immediate transfer of knowledge within the organisation in order to share changes and challenges that can be potentially faced by more than one team. Indeed, project complexity can actually encourage project teams to share knowledge with each other, providing benefits on the overall performance of both single project teams and the project-based organisation (Park and Lee, 2014). Moreover, Sorenson (2003) shows that integration can facilitate learning-by-doing activities by constituting a buffer preventing the company from external instability (i.e. caused from the external environment); this is true especially in correlation with an increase in volatility of the external environment. In Fincantieri the top management fosters the access to a variety of standardised tools such as common WBS and cost structures, product and production engineering, process maps, datasheet in the enterprise resource planning system, previous ship review. While these tools are mainly standardised and common to different teams, the organisational procedures to access the knowledge created (such as the changes and related problems) in other projects are not. Beyond standardised roles and procedures, good and best practices are formally and constantly collected to be included in a common base of knowledge within the organisation.

Less formal initiatives are privileged for codifying and sharing knowledge on specific issues, emerging from the day-to-day management. Indeed, the diversification of portfolio in terms both of newness and uniqueness requires informal mechanisms for specific challenges. While project management practices are shared (i.e. WBS for the ship platform), the uniqueness of each project allows learning patterns that are enhanced at the overall level. Indeed, each project lifecycle is unique due to the boundary conditions, but foremost by the people who work together (in a team configuration) for its effective development and delivery. The management of projects mainly relies on the ability of people "to engage intelligently with the complexity of projects" (Winter et al., 2006). The results show that bringing the knowledge acquired in a project to the following ones (and the others ongoing) has no dedicated formal procedures. Without strict regulations or top-down directions, the project management teams are compared to entities that self-organise and maintain informal connections that enable constant sharing and exchange of knowledge. Adding to this, in order not to lose the knowledge gained (Brady and Davies, 2004), the information that is created and shared from the bottom-up must be properly stimulated in order not to remain constrained to the interpersonal relations. Therefore, the case shows that dealing with the dimensions of diversity, interdependence, dynamicity and uncertainty in the project portfolio requires to promote informal meetings where all the interested parts are called to share a series of reflections on the more structured, across-projects level processes, in order to address specific issues that could become synergic among multiple projects and respond to both customer and internal integration needs. This consideration implies the adoption of tools and not restricted, bureaucratic procedures to access the solutions already implemented and to stimulate organisational routines. Indeed, the interviewees claim that useful practices such as the formal reviews at the end of the projects evolved in a bureaucratic procedure that it seen more as an interruption rather a support for the daily work. Senior management can intervene at any time by initiating far-reaching organisational changes, and processes may be put in place so that the new project activities can be "routinized" (Brady and Davies, 2004).

Finally, the company under study shows a positive attitude towards the creation of knowledge communities. These identify a sort of professional clusters, with the definition of clear roles and responsibilities and career paths, which are built basing on the uniqueness of a project and the experiences of different members as a qualifying feature that enhances the whole organisation to make it common knowledge. Through the integration of the unique features with the collaboration and cooperation to face the increasing complexity when undertaking project tasks, the project team enhances organisational learning (Sorenson, 2003) and accumulates project knowledge that can be promptly shared with the other teams showing similarities. Overall, the initiatives made to capture the cumulative learning from previous and ongoing projects and to institutionalise new knowledge and processes based on those learning experiences (Keegan and Turner, 2001) enable an innovation of the overall project management practice of the organisation.

CONCLUSIONS

C.1 RESEARCH RESULTS: ANSWERS TO THE RESEARCH QUESTIONS

This study explores how organisations are dealing with the increasing complexity of their projects from an organisational learning perspective. It contributed to achieving three mains aims: (1) to develop a systematic literature review on project complexity, with the identification of related main research streams and future research directions; (2) to propose an organisational learning perspective as an emerging feature of project complexity, with a focus on related processes and challenges, and (3) to study project complexity and organisational learning processes and main issues in an embedded case study, deriving implications at both within and across projects level.

The systematic literature review allowed to collect a total of 47 contributions on project complexity as reference body of knowledge to identify the main research streams. We analysed their distribution by adopted methodology, level of analysis, sample dimension, data collection methods and tools, key informants, industry or type of project. The following thematic analysis identified the main topic areas under investigation and the current debates of scholars and practitioners. Four fundamental themes were identified as: understanding and characterising project complexity (with a further focus on definitions and different perspectives that affect the division of the current definitions along dual perspectives, dimensions and types, determinants, perspectives and theoretical lenses), measuring project complexity, studying the relationship between project complexity and performance, identifying practices and strategies to cope with complexity. This allowed us to define patterns and linkages among the main themes and to frame a holistic view on the current research on project complexity. We then concluded that project complexity literature needs further contributions for methodological, theoretical and thematic issues. Basing on the gaps and the possible future research directions per each issue, we formulated the research questions guiding the investigation conducted in this thesis.

In this paragraph, a brief answer to each research question is reported, by referring to the results obtained in the empirical section (Chapters 4 and 5). The will to gain deeper insights on the elements of complexity in a multi-project environment, such as project-based organisations, and the connected hierarchical aspects and the emerging dynamics, brought us to review main definitions and issues on organisational learning in project environments. This allowed us to strengthen the theoretical background for the following empirical study. The analysis on the 'knowing' as the dimension of knowledge linked both to the operational and organisational level allowed to appreciate the organisational learning as a unique and unrepeatable pattern in front of the accounted complexity of the project. We employed an embedded case study research design to perform an in-depth study of the dimensions of project complexity and organisational learning in one company of the shipbuilding industry, embedded within which are multiple levels of analysis. The results obtained were then organised into an interpretative framework for complexity and organisational learning (1) within and (2) across projects. The framework provides a reference and specific suggestions for future research aiming to investigate the learning dynamics within environments characterised by a level of complexity, temporary organising and short-term objectives focus. Here below we provide the overview of the findings by discussing them in the light of the two research questions.

1) How do organisations understand and face project management complexity within their projects from an organisational learning perspective?

Project management complexity within projects proved to be characterised by four dimensions: diversity, interdependency, dynamicity and uncertainty. Projects show a different level of complexity, resulting from the combination of the different dimensions, as each of them has unique, one-off characteristics that distinguish it from the others – even if carried out within the same organisation. Main processes to be considered in the analysis of project complexity from an organisational learning perspective are experience accumulation, knowledge acquisition and knowledge codification, as emerging throughout the project implementation.

In general, complex projects show a considerable level of all the sub-processes of organisational learning, taking place in the project team. For instance, a higher level of both interdependency and dynamicity results in a higher knowledge codification. Beyond the experience of the project team members, dealing with several interfaces (e.g. customers, suppliers, subcontractors, other functional units) and pace of the projects (e.g. introduction of several changes during the implementation phases, strict regulations) allows for a better learning at organisational level. A higher diversity mainly results in the need to acquire knowledge from the external sources, and in particular on the previous projects, the previous experiences of the team members and also the competences of the main stakeholders, when properly shared. The dynamicity requires both knowledge acquisition and codification, mainly addressing issues that are specific of the ongoing project at the operational level. Finally, higher uncertainty requires relying on the ongoing experience-based learning.

This study shows that organisations, especially the project-based ones, should consider the operational tasks (i.e. carried out by the project management teams), the managerial initiatives (i.e. the ones promoted by the wider organisational level), and the project uniqueness features (being a qualifying feature for the learning of the overall organisation, as it is also linked to the uniqueness of the teams) when considering possible practices and strategies to cope with project complexity. Focusing on the processes of experience accumulation, knowledge acquisition and knowledge accumulation, the resulting interpretative framework for complexity and organisational learning in project environments determines further insights on studying organisational learning as an emergent process. Overall, the complexity of projects tends to bring to informal mechanisms of knowledge codification and knowledge communities formation, to be properly shared and transferred in the upcoming projects.

2) How can organisations face project management complexity across their projects from an organisational learning perspective?

Dealing with multiple projects carried out in parallel has several implications also on the organisational learning processes that can take from project to project and from the single projects to the overall organisation. The project management teams have to face several interfaces at the operational level, mainly due to the conflicts between the temporary organising and the presence of multiple stakeholders. Dealing with the dimensions of diversity, interdependence, dynamicity and uncertainty in the project portfolio requires to promote informal practices to share reflections on the more structured, across-projects level processes, in order to address specific issues that could become synergic among multiple projects and respond to both customer and internal integration needs. This consideration implies the adoption of tools and not restricted, bureaucratic procedures to access the solutions already implemented and to stimulate organisational routines. From the one side, higher levels of diversity among projects require a systematic knowledge codification in knowledge management systems for consolidated project management practices. From the other, the dynamicity due to the management of projects in parallel requires the integration between the bottom-up experience, especially in terms of changes and challenges that can be potentially faced by more than one project team, and top-down initiatives from the overall organisation, such as the creation of knowledge communities.

C.2 THEORETICAL CONTRIBUTIONS

This study represents, according to the knowledge of the researcher, a first effort to link complexity dimensions and learning mechanisms in project environments. The interpretative framework, resulting from the analysis within and across projects embedded in an organisation, builds on:

- four dimensions of complexity, derived among the dimensions and types of project complexity most cited ion the related literature: diversity, interdependency, dynamicity, uncertainty;
- three key processes of organisational learning, i.e. knowledge creation through experience accumulation, knowledge acquisition (from other sources or contexts), knowledge codification, in addition to the emphasis on the short-term performance and the compliance with the project constraints; and the dispersed system of practice among the project teams, with the need to identify proper ways to capture, share and transfer knowledge in temporary and project-based organisations, such as the creation of the so-called "knowledge communities" (Lindkvist, 2005).

The framework highlights and builds on the integration between project complexity and organisational learning issues to uncover areas for future research and theory development. The contributions and added value of this thesis for literature are threefold.

Firstly, the systematic literature review on project complexity allowed to identify the main research topics (i.e. understanding and characterising project complexity, measuring project complexity, the relationship between project complexity and performance, the practices and strategies to cope with complexity), the main gaps (at methodological, theoretical and thematic level) and outlined possible directions for future research. This thesis might guide scholars that are interested in studying project complexity and related issues by clearly addressing these directions and possibly grounding them on well-established theoretical foundations.

Secondly, taking into account the organisational learning process as a perspective for understanding complexity allowed to further enrich the insights obtained from the conceptualising of complexity in a project environment. This study is in line with other studies in project management research that has frequently integrated models and concepts from other disciplines, with a caution in applying theories to the contextual nature of projects (Smyth and Morris, 2007). This thesis contributed with empirical evidence for studying how dealing with complexity results in an emerging process of organisational learning in project-based organisations and project management practices. Specifically, major features of project-based organisations considered in the analysis were: (1) the emphasis on the short-term performance (i.e. tasks completion) and the challenges linked to the compliance with the project constraints; and (2) the dispersed system of practice resulting from the decentralisation of tasks (Bresnen et al., 2005), with the need to identify proper ways to capture, share and transfer knowledge in temporary and project-based organisations, such as the creation of the so-called "knowledge communities" (Lindkvist, 2005).

We developed an interpretative framework on two dimensions, represented by (1) the dimensions of complexity mainly cited in the literature on project complexity, (2) the key sub-processes and challenges of organisational learning in ongoing projects (situated or practice-based learning). While developing such a framework, we also refined the dimensions and types of project complexity, thus enriching this area of project-oriented literature.

From a methodological point of view, the embedded case study design allows for deepening the analysis at both within and across projects. We investigated the themes of project complexity and organisational learning within the project management practice, as it is one of the key knowledge domains for the organisational performance, especially in project-based organisations (Bartsch et al., 2013). Moreover, we followed the emerging research field that conceptualise project management as an organisational practice, where learning becomes mutually constituted with the management of the project as a practice (Ahern et al., 2014; Winter et al., 2006). The same variables were investigated at both within and across team levels (in the multi-projects environment), as the emerging patterns of complex systems can be observed at different scales, from groups to the overall organisation (Mitleton-Kelly and Ramalingam, 2011).

Finally, the empirical case illustrates these themes from an in-depth study of the unique characteristics of the shipbuilding industry, and specifically one of the leading players. The dimensions of analysis contribute to the literature on project-based organising and temporary organisations with a focus on the organisational learning processes. The focus on distinct levels of analysis that reflects the hierarchy of complex systems confirms the effectiveness of project-based organising, with distributed knowledge and bottom-up initiatives, to face project complexity.

C.3 PRACTICAL CONTRIBUTIONS

From the practitioners' point of view, this thesis provides useful suggestions for the development of project management discipline with a focus on the management of complexity and the organisational learning processes.

The achieved results can represent an overview of the possible ways for managers and organisations, especially the project-based ones, to deal with the complexity in projects and project management. It deepens the current issues on understanding, characterising, measuring, identifying practices and strategies to cope with and the consequent learning processes at the organisational level. This is of particular relevance considering the prominent role of project organising and dealing with the increasing complexity of the competitive environment.

The proposed dimensions may help project managers and other project stakeholders to better understand the complexity of the projects they are working on. This approach would support them in positioning their projects in terms of emerging patterns and their fit with the knowledge management strategies actually promoted within their organisations. A dedicated evaluation would provide them with a basis to eventually adjust their project management practices and/or organisational learning processes accordingly. The four dimensions (and related types) of project complexity and the main issues of organisational learning in project environments (processes, constraints and the organisational practices to capture, share and transfer knowledge in temporary and project-based organisations) that have been highlighted in this thesis could be considered by project managers and in general people working in projects when identifying the proper mechanisms to foster knowledge creation and sharing in their companies.

Implications for project management practitioners are mainly in viewing the processes of knowledge development (by experience accumulation and acquisition from other projects, stakeholders and sources) and knowledge codification as resulting from the operational level (i.e. project management activities). While practitioners-oriented references such as the PMBOK (PMI, 2013a) provide prominently suggestions on how framing the knowledge management systems to foster sharing and transfer of tools and practices, mainly basing on a deterministic perspective (Padalkar and Gopinath, 2016b), the focus on the dynamics and emerging features arising from project complexity can integrate and overcome the "one-size-fits-all" approach (Shenhar, 2001). In this sense, lining the two perspectives can help project managers to habilitate day-by-day mechanisms of learning at the operational level and the organisational functions to better sustain the creation of the environment to these mechanisms to take place. Top-down initiatives should be addressed to stimulate informal mechanisms of articulation and codification, without imposing standardisation but enabling harmonisation, especially in highly dynamic project environments. The identified processes, issues and practices can help managers reflect on motivations, behaviours and organisational initiatives to foster knowledge creation through experience, acquisition from several sources and codification into new and improved tools and practices to be consecutively shared with the overall organisation.

Another important implication is the focus on the shipbuilding industry, one the most complex ones for decision-making, due to the variety, level of interconnections, dynamicity and uncertainty of the overall context, allowed us to provide managerial insights into this industry. The analysed case highlighted organisational and operational choices and practices carried out by one of the main players of the industry. Moreover, main dimensions of complexity in cruise ship projects were identified and their relationships with the elements of the project system were analysed. Finally, these were discussed in light of the organisational processes taking place in the ongoing projects.

C.4 LIMITATIONS AND SUGGESTIONS FOR FUTURE RESEARCH

The results of this thesis should be viewed in light of several limitations. Major limitations are linked to the choice of the research design, i.e. the single case study and the qualitative data analyses performed. The interpretivist approach has been demonstrated in being poor in addressing the general (Smyth and Morris, 2007). Despite generalisability is limited, this explorative study allowed to reveal possible patterns, and a statistical analysis on a wider sample would sustain a better formulation of the hypotheses and operationalisation of the variables. As regards the employed methods, the collection of data by informants may be difficult and in certain cases biased, but significant efforts were done by us to maximise the reliability, for example by using multiple data collection techniques and interviewing multiple informants.

We provided a set of hypotheses in an interpretative framework that could be formalised into a model and tested empirically in future studies. The framework could benefit from more clarification on the type of mechanisms and units of analysis to be considered, and further extended to processes such as the transfer of knowledge created and codified within the single units.

Moreover, the selection of the case and the boundaries established in the design of the research limited the scope of the study. Therefore, a multiple case study, on a multi-sectoral basis, would allow to extend and refine the lessons learned here. Caution is required in extending findings to companies of different dimensions (e.g., small and medium enterprises), belonging to different industries (e.g., the construction sector), and with different organisational settings (e.g. not pure project-based but organisations carried out other sort of projects). Anyway, shipbuilding is one of the most complex environments for decision making, with the employment of key project management practices and tools, and big companies are more likely to deal with issues linked to organisational learning processes and mechanisms to foster knowledge creation, codification and sharing among a high number of members and with loose linkages.

A further interesting direction for future research concerns the selection of managerial and organisational practices to foster organisational learning with different levels of diversity, interdependency, dynamicity and uncertainty. Additional studies may be conducted to formalise and empirically test a model per each dimension of complexity and each learning process to be studied.

Finally, as this thesis considered the learning process within the boundaries of a single organisation, further research could deepen the analysis on the inter-organisational level, further elevating in the hierarchy of complex systems in project environments.

APPENDIXES

APPENDIX A. THE PROCESS OF SYSTEMATIC LITERATURE REVIEW

With the aim of exploring current topics of discussion on project complexity and enhance a robust knowledge base (Tranfield et al., 2003) accounting of past research (Cooper, 1998), a systematic literature review was performed. This methodology allows to synthesise and assess the available studies on the topic investigated in a reliable and reproducible manner (Tranfield et al., 2003; Geraldi et al., 2011).

The general aim of a literature review is to give a critical overview of the existing knowledge in a field of inquiry with a format and a scope that vary accordingly to the discipline, the topic and the research question under investigation. This appendix describes the approach adopted in this study.

Aiming to address the underlying principles of transparency, inclusivity and pertinence to the specific research question (Rousseau et al., 2008; Denyer and Tranfield, 2009), the process of sources selection and analysis builds on and combines the approaches of "systematic review" proposed by Tranfield et al. (2003) and Petticrew and Roberts (2006).

The main method is keywords search in electronic databases. The selected keywords were identified from a selection of publications on major project management journals, with the aim of restricting the base of knowledge to studies clearly defining complexity from both complexity theory and project management research and practice point of view. The process of studies selection and evaluation resulted in a total of 47 peer-reviewed articles, published over a period of 21 years (from 1996 to 2017) in 17 academic journals belonging to the subject areas of business, construction and building, engineering and operations management. The articles were classified according to different criteria and both descriptive and thematic findings were identified.

The entire process was performed by a single reviewer following the principles of selectivity and neutrality (Cooper, 1998; Hart, 1998), ensuring consistency with the aims of the review and allowing a posterior review thanks to the replicable process description (Lehtiranta, 2014).

The descriptive and thematic findings are described in Chapter 1.

A.1 Data sources and search strategy

In order to identify all studies contributing to a thorough understanding of the topic investigated, the research question was initially broken down into the keywords *complexity* and *project*.

In the first step, an exploratory search was performed in the top journals in the field of project management, i.e. International Journal of Project Management (IJPM), Project Management Journal (PMJ), and International Journal of Managing Projects in Business (IJMPB) (Padalkar and Gopinath, 2016b). Articles having the combination "complexity AND project" in the title were selected and thoroughly scanned in order to identify the different connotations used in literature for defining complexity in projects. An iterative refinement of keywords and combination of keywords based on the early sample from literature allowed to identify all the connotations used for the concepts of (1) complexity and (2) project.

The final search strings for the study shown in Table A.1. While considered in a first attempt, the combination "complex project" was excluded in this step. The motivation is twofold: (1) the adjective complex refers to a specific class of projects, while the term "project complexity" or "complexity of projects" includes the aspects that define a project as complex (Bosch-Rekveldt et al., 2011); 2) many authors refer to complex projects as large or multiple projects or programmes (Thomas and Mengel, 2008), "without the explicit concept of complexity science and theory in mind" (Aritua et al., 2009, p. 76). Along the latter point, the application of complexity theory enables a systematic consideration of the factors contributing to complexity in the management of projects (Antoniadis et al., 2011). From this first search, 36 articles were selected.

In the following step, two major electronic databases, i.e. Scopus and ISI Web of Science, were scanned for searching the different combinations. The integration of the two databases allowed indeed covering both a wide journal range and a large time span (Falagas et al., 2008). The articles including at least one of the research strings in title, keywords or abstract were selected for further analysis.

A.2 Articles selection and exclusion

Since projects and project management issues are a multi-sectoral and multi-disciplinary topic that has been studied in several academic areas, the keywords search was performed without any reduction in the scope of the sources to consider. It was limited to articles published in English peer-reviewed journals, while conference papers, industry reports, books and books reviews were excluded, in the attempt to ensure the inclusion of only high-quality and reliable sources. After the further elimination of duplicates, the search strategy allowed to identify a total of 1716 contributions.

In the following step, titles and abstracts of these works were thoroughly scanned. The sample was further discussed after full-text reading. Subsequently, the works in which complexity or complex projects were simply cited, without a direct reporting or further analysis contributing to advance knowledge on the specific topic under investigation, were hand-selected for exclusion.

Finally, the process of selection followed the advice of Greenhalgh and Peacock's (2005) to extend the search beyond keywords for inclusiveness, for example by carrying out a snowball backward search. Therefore, a thorough review of the references listed in the identified publications was performed, with a further attention for the references included in the previous literature reviews on project complexity. This last step, carried out by using the previous criteria for exclusion and ensuring that no significant sources were missed, increased the number of total selected studies to 47.

The strategy of search and selection of contributions is summarised in Table A.1.

Table A.1 – Literature search and selection criteria

KEYWORDS	COMPLEXITY • complexity • "project complexity" • "complexity in project" • "complexity of project"
	PROJECT • "project management" • "project environment" • "project-based" • "project-oriented" • "project-led"
SEARCH STRINGS	("project management" OR "project environment" OR "project-based" OR "project-oriented" OR "project-led") AND complexity "project complexity" OR "complexity in project" OR "complexity of project"
DATABASES	Scopus ISI Web of Science
FIELDS	Title, Abstract, Keywords (Scopus) Topic (ISI Web of Science)
SUBJECT AREAS	All
SELECTION CRITERIA	▪ Only documents written in English language ▪ Only papers in peer-reviewed journals ▪ Only papers strictly focused on complexity in projects and in project management ▪ Exclusion of document types: conference papers, industry reports, books, books reviews ▪ Exclusion of papers dealing with projects defined as "complex" but have no relationship to the explicit concept of project complexity ▪ Exclusion of papers studying complex projects as settings for investigation of other phenomena

A.3 Coding process

The 47 articles were coded in order to obtain an overview of them along with several evaluation dimensions. The rules used to code the publications were defined a priori. Definitions and possible values of the evaluation dimensions adopted are reported in Table A.1.2.

A preliminary analysis confirmed that all different perspectives and aspects of the research domain had been identified. The first descriptive results helped to group the papers before detailed analysis. Finally, all selected articles were critically analysed as regards thematic content to identify main topics for discussion.

Table A.2 – Coding

CODES	DEFINITION	VALUES
Authors	All the authors that co-authored the article	-
Year	Year the article appeared in published form	-
Journal outlet	Journal the article was published in	-
Research purpose	Intention underlying the article, basing on definitions by Voss et al. (2002)	Descriptive, Exploration, Theory building, Theory testing, Theory extension/refinement
Methodology	Methodological approach employed in the article (Easterby-Smith et al., 2000). Mixed method refers to the use of more than one method	Literature review, Conceptual, Case study, Survey, Delphi method, Mixed methods
Level of analysis	Object of the study, as specified by the paper or inferred by the researcher	Single dimension (whether one single dimension or type of complexity is considered), Multiple dimensions, Project, Multi-projects, Programme, Project management
Sample dimension	Size of the sample in an empirical study	Number of case studies, size of the population of a survey
Data collection	Methods and tools used to collect data in an empirical study	Examples: semi-structured interviews, questionnaires, meetings
Key informants	Number and type of sources of knowledge in an empirical study, specifically the ones employed in the data collection phase	Examples: project managers, CEO, academics, industrial experts
Type of project	Context of analysis defined on the base of the product of the project, as specified by the article or inferred by the researcher. It can refer to an industry, sector, type of output of an organisational project	Examples: Construction, Infrastructure, Building, Software development, Aerospace
Research topic	Main topic area of the article	Understanding and characterising project complexity, Measuring project complexity, Relationship between project complexity and performance, Practices and strategies to cope with complexity

A.4 Findings reporting

A final analysis allowed to evaluate and then discuss the research findings according to different criteria, in order to provide a comprehensive overview of major trends and implications of previous studies on project complexity. Finally, contributions were further examined for identifying possible future research directions. Findings are reported in this thesis as follows. Descriptive findings are presented in Paragraph 1.2. Thematic findings and main topics under investigation (i.e. relating to the 'Research topic' classification) are presented in Paragraphs 1.3, 1.4, 1.5, 1.6. Finally, research directions identified in the selected studies and in this thesis are reported in Paragraph 1.7.

APPENDIX B. DATABASE FOR THE LITERATURE STATE OF THE ART

This appendix shows the database obtained after the coding process, by collecting the references selected in the literature review process.

Table B.1 – Set of reviewed articles

N.	AUTHOR(S)	YEAR	JOURNAL OUTLET	RESEARCH PURPOSE	METHODOLOGY	LEVEL OF ANALYSIS	SAMPLE DIMENSION	DATA COLLECTION	KEY INFORMANTS	TYPE OF PROJECT	RESEARCH TOPIC
1	Antoniadis D.N., Edum-Fotwe F.T. , Thorpe A.	2011	International Journal of Project Management	Theory testing	Case study	Single dimension	5 projects	Weekly meetings and validation interviews	Board directors and project managers	Construction	Relationship between project complexity and performance
2	Aritua B., Smith N.J., Bower D.	2009	International Journal of Project Management	Exploration	Conceptual	Multi-projects	-	-	-	Construction	Understanding and characterising project complexity
3	Azim, S., Gale, A., Lawlor-Wright, T., Kirkham, R., Khan, A., Alam, M.	2010	International Journal of Managing Projects in Business	Theory testing	Mixed methods	Project manageme nt	-	Qualitative questionnaires	Practitioners	Aerospace	Understanding and characterising project complexity
4	Baccarini D.	1996	International Journal of Project Management	Description	Conceptual	Multiple dimensions	-	-	-	Construction	Understanding and characterising project complexity
5	Bakhshi J., Ireland V., Gorod A.	2016	International Journal of Project Management	Description	Literature review	Project	-	-	-	-	Understanding and characterising project complexity
6	Benbya, H., McKelvey, B.	2006	Information Technology and People	Description	Conceptual	Project	-	-	-	Information systems	Practices and strategies to cope with complexity

N.	Author(s)	Year	Journal Outlet	Research purpose	Methodology	Level of analysis	Sample dimension	Data collection	Key informants	Type of project	Research Topic
7	Bosch-Rekveldt M., Jongkind Y., Mooi H., Bakker H., Verbraeck A.	2011	International Journal of Project Management	Theory extension / refinement	Case study	Project	6 projects within 1 company	Semi-structured interviews and project documentation	Project manager, a team member and an owner representative of each project	Engineering	Understanding and characterising project complexity
8	Brady T., Davies A.	2014	Project Management Journal	Theory extension / refinement	Case study	Programme	2 megaprojects	Interviews and secondary data (official documents, presentations, contracts, reports, and the trade press)	Senior managers working in different organisations (clients, contractors, other stakeholders)	Construction	Practices and strategies to cope with complexity
9	Chapman R.J.	2016	International Journal of Project Management	Theory extension / refinement	Mixed methods	Multiple dimensions	1 megaproject	-	-	Transportation	Understanding and characterising project complexity
10	Cicmil S., Marshall D.	2005	Building research and information	Theory extension / refinement	Case study	Single dimension	1 project	Semi-structured interviews, documentary analysis and direct observations	Team members	Construction	Understanding and characterising project complexity
11	Cooke-Davies T., Cicmil S., Crawford L., Richardson, K.	2007	Project Management Journal	Exploration	Conceptual	Project management	-	-	-	-	Understanding and characterising project complexity
12	Dao B., Kermanshachi S., Shane	2017	Journal of Construction Engineering	Theory testing	Survey	Project	44 projects	Questionnaire	Industry practitioners	Construction	Understanding and characterising

N.	AUTHOR(S)	YEAR	JOURNAL OUTLET	RESEARCH PURPOSE	METHODOLOGY	LEVEL OF ANALYSIS	SAMPLE DIMENSION	DATA COLLECTION	KEY INFORMANTS	TYPE OF PROJECT	RESEARCH TOPIC
	J., Anderson S., Hare E.		and Management								project complexity
13	Davies A., Mackenzie I.	2014	International Journal of Project Management	Theory extension / refinement	Case study	Programme	1 programme (megaproject) and 5 specific projects	Interviews and secondary data (official documents, presentations, contracts, baseline reports, and the trade press)	Senior managers (chairman, CEO, directors, project managers, project sponsors, project directors)	Construction	Practices and strategies to cope with complexity
14	Dawidson O., Karlsson M., Trygg L.	2004	International Journal of Information Technology & Decision Making	Description	Case study	Project	2 projects	Semi-structured interviews	Project members	Telecommunication (technology)	Understanding and characterising project complexity
15	Floricel S., Michela J.L., Piperca S.	2015	International Journal of Project Management	Theory testing	Survey	Project	81 projects	Questionnaire	Practitioners	Energy, water, telecommunication infrastructure, mining and manufacturing facilities, sports, cultural, urban and tourism facilities	Relationship between project complexity and performance

N.	Author(s)	Year	Journal Outlet	Research purpose	Methodology	Level of analysis	Sample dimension	Data collection	Key informants	Type of project	Research Topic
16	Geraldi J.	2009	Technology Analysis and Strategic Management	Theory testing	Case study	Project	7 projects of the same company	Project meetings, interviews, documentation	People working on projects	Plant engineering	Understanding and characterising project complexity
17	Geraldi, J., Adlbrecht, G.	2007	Project Management Journal	Theory building	Mixed methods	Multiple dimensions	7 project managers	Multiple choice questionnaire, semi-structured interviews	Project managers	Plant engineering	Measuring project complexity
18	Geraldi J., Maylor H., Williams T.	2011	International Journal of Operations and Production Management	Description	Literature review	Multiple dimensions	-	-	-	-	Understanding and characterising project complexity
19	Gidado, K.I.	1996	Construction Management and Economics	Description	Conceptual	Multiple dimensions	-	Interviews and literature	Experts in construction industry	Building/construction	Understanding and characterising project complexity
20	Giezen	2012	International Journal of Project Management	Theory extension / refinement	Case study	Project	1 large project	Interviews and secondary data (newspaper, policy documents)	Project managers, aldermen, company officials, people involved in contextual policy (government officials, strategists, academic expert)	Infrastructure	Practices and strategies to cope with complexity

N.	AUTHOR(S)	YEAR	JOURNAL OUTLET	RESEARCH PURPOSE	METHOD OLOGY	LEVEL OF ANALYSIS	SAMPLE DIMENSION	DATA COLLECTION	KEY INFORMANTS	TYPE OF PROJECT	RESEARCH TOPIC
21	Gransberg D.D., Shane J.S., Strong K., Lopez del Puerto C.	2013	Journal of Management in Engineering	Theory extension / refinement	Case study	Multiple dimensions	18 projects	Interviews and secondary data (archival project documents, public records, news and trade publication, journal article)	Project participants	Infrastructur e	Measuring project complexity
22	He, Q., Luo, L., Hu, Y., Chan, A.P.C.	2015	International Journal of Project Management	Theory extension / refinement	Mixed methods	Multiple dimensions	1 megaproject	Literature, Delphi questionnaire	Managers from real estate developers, construction companies, consultancy firms, government departments, universities	Contruction	Measuring project complexity
23	Jaafari, A.	2003	Project Management Journal	Exploration	Conceptual	Project manageme nt	-	-	-	-	Practices and strategies to cope with complexity
24	Kapsali, M.	2013	Systems Research and Behavioral Science	Exploration	Conceptual	Project manageme nt	-	-	-	-	Practices and strategies to cope with complexity
25	Kiridena, S, Sense, A.	2016	Project Management Journal	Theory extension / refinement	Literature review	Project	-	-	-	-	Understanding and characterising project complexity
26	Lessard, D., Sakhrani, V., Miller, R.	2014	Engineering Project Organisation Journal	Theory testing	Case study	Multiple dimensions	20 large projects	Interviews, questionnaires	Participants, project sponsors	Large infrastructure	Understanding and characterising project complexity

N.	AUTHOR(S)	YEAR	JOURNAL OUTLET	RESEARCH PURPOSE	METHODOLOGY	LEVEL OF ANALYSIS	SAMPLE DIMENSION	DATA COLLECTION	KEY INFORMANTS	TYPE OF PROJECT	RESEARCH TOPIC
27	Lu Y, Luo L., Wang H., Le Y., Shi Q.	2015	International Journal of Project Management	Theory testing	Mixed methods	Project	1 large project	-	-	Construction	Measuring project complexity
28	Luo, L., He, Q., Jaselskis, E.J., Xie, J.	2017	Journal of Construction Engineering and Management	Description	Literature review	Project	-	-	-	Construction	-
29	Luo, L., He, Q., Jianxun, X., Yang, D., Wu, G.	2017	Journal of Management in Engineering	Theory testing	Survey	Project	245 project managers	Questionnaire	Project managers	Construction	Relationship between project complexity and performance
30	Maylor H., Vidgen R., Carver S.	2008	Project Management Journal	Exploration	Mixed methods	Multiple dimensions	-	Workshops	Project managers	Telecommunication, defence, transportation	Understanding and characterising project complexity
31	Nguyen A.T., Nguyen L.D., Le-Hoai L., Dang, C.N.	2015	International Journal of Project Management	Theory extension / refinement	Fuzzy AHP	Project	148 professionals	Questionnaire	Professionals from owners and contractors	Transportation	Measuring project complexity
32	Padalkar, M., Gopinath, S.	2016	International Journal of Project Management	Description	Literature review	Single dimension	-	-	-	-	-
33	Pich, M.T., Loch, C.H., De Meyer, A.	2002	Management Science	Theory building	Conceptual	Project	-	-	-	-	-
34	Pundir, A.K, Ganapathy, L.,	2007	Emergence: Complexity	Description	Conceptual	Project	-	-	-	-	-

N.	Author(s)	Year	Journal Outlet	Research purpose	Methodology	Level of analysis	Sample dimension	Data collection	Key informants	Type of project	Research Topic
	Sambandam, N.		and Organisation								
35	Qazi, A., Quigley, J., Dickson, A., Kirytopoulos K.	2016	International Journal of Project Management	Theory extension / refinement	Mixed methods	Project	13 experts	Semi-structured interviews	Experts in construction industry	Construction	Practices and strategies to cope with complexity
36	Qureshi S.M., Kang C.W.	2015	International Journal of Project Management	Theory building	Survey	Single dimension	150 practitioners	Questionnaire	Project consultants, project managers, project director	Construction, textile, IT, automobile, R&D	Measuring project complexity
37	Saynisch, M.	2010	Project Management Journal	Exploration	Conceptual	Project management	-	-	-	-	-
38	Senescu, R.R., Aranda-Mena, G., Haymaker, J.R.	2013	Journal of Management in Engineering	Theory testing	Case study	Project	2 projects	Structured interviews	Architect, structural engineer, drafter, project manager, BIM coordinator, quantity surveyor, design technology director.	Construction	Practices and strategies to cope with complexity
39	Shenhar, A.J.	2001	Management Science	Exploration	Mixed methods	Project	29 projects in 16 companies	Interviews, observations, questionnaires	Project managers	Aerospace, defence, electronics, computer, construction	Practices and strategies to cope with complexity
40	Sommer, S.C., Loch, C.H.	2004	Management Science	Theory building	Conceptual	Project	-	-	-	Innovation	Practices and strategies to cope with complexity

N.	AUTHOR(S)	YEAR	JOURNAL OUTLET	RESEARCH PURPOSE	METHOD OLOGY	LEVEL OF ANALYSIS	SAMPLE DIMENSION	DATA COLLECTION	KEY INFORMANTS	TYPE OF PROJECT	RESEARCH TOPIC
41	Thomas J., Mengel T.	2008	International Journal of Project Management	Exploration	Conceptual	Project	-	-	-	-	Practices and strategies to cope with complexity
42	Vidal L.-A., Marle F.	2008	Kybernetes	Theory building	Conceptual	Multiple dimensions	-	-	-	-	Understanding and characterising project complexity
43	Vidal L.-A., Marle F., Bocquet J.-C.	2011	International Journal of Project Management	Theory testing	Mixed methods	Multiple dimensions	7 projects	Structured interviews	Academic and industrial experts in PM for Delphi, team members for case study	Production of stage musicals	Measuring project complexity
44	Whitty S.J., Maylor H.	2009	International Journal of Project Management	Exploration	Conceptual	Project manageme nt	-	-	-	-	Understanding and characterising project complexity
45	Williams T.M.	1999	International Journal of Project Management	Exploration	Conceptual	Multiple dimensions	-	-	-	-	Understanding and characterising project complexity
46	Xia B., Chan A.P.C.	2012	Engineering, Construction and Architectural Management	Theory extension / refinement	Delphi method	Project	-	Questionnaire	Experts (most senior positions) with experience in building industry	Building	Measuring project complexity
47	Zhu, J., Mostafavi, A.	2017	International Journal of Project Management	Theory extension / refinement	Case study	Multiple dimensions	-	Semi-structured interviews	Senior project managers	Construction	Relationship between project complexity and performance

APPENDIX C. INTERVIEW GUIDELINE FOR DATA COLLECTION

INTRODUCTION TO THE INTERVIEWEE:

- thanks for the participation in the study
- purpose of the research project: *investigating how project-based organisations (especially the project-based ones) deal with the complexity of their projects from an organisational learning perspective*
- meaning of project complexity: *project as a system composed by numerous elements, varied and interrelated, whose interaction through interfaces results in properties of the overall system (project) and a behaviour not linear and not always predictable*
- contribution of the interviewee
- expected duration of the interview
- terms of confidentiality
- use of a tape recorder

Years of experience in Fincantieri: ____

Current project being involved: ____

Current phase of the project: ____

Role in the project: ____

Previous professional experience: ____

1. Please briefly describe the project history.

2. Basing on your experience, how would you define this project as complex from a technical/ technological point of view?

3. And as complex from an organisational point of view?

4. And as complex from the environment (e.g. stakeholders) point of view?

5. What is the knowledge required for the management of the project (e.g. procedures, documentation, tools)?

6. What knowledge did you employ basing on the previous experience (e.g. procedures, documentation, tools)?

7. What did you learn throughout this project (e.g. new / changed procedures, new/changed documentation, new/changed tools)?

8. What are the determinants of this learning (e.g. top management initiatives, customers, project constraints, knowledge management systems)?

9. What are the mechanisms by which the knowledge acquired within the project is coded to be shared with the other project management teams?

10. What are the mechanisms by which the knowledge acquired within the project is coded to be shared with the overall organisation?

10. What are the determinants of this knowledge sharing (e.g. top management initiatives, project constraints, procedures)?

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