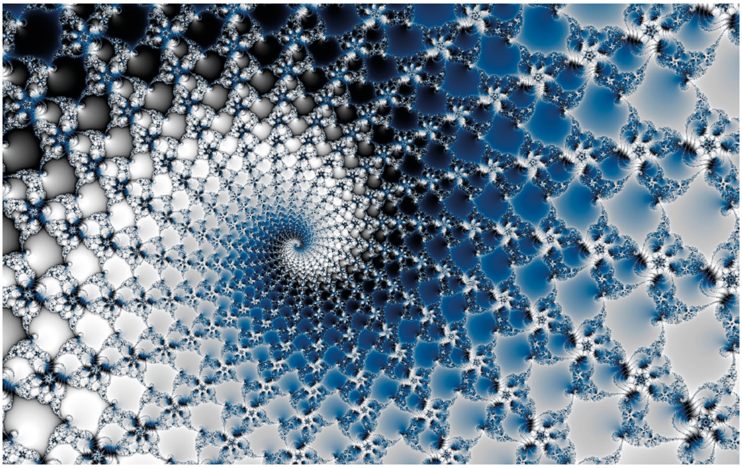
Convegni

Scienze e Tecnologie

Project Management

Driving Complexity
PMI® Italian Academic Workshop

edited by
Fabio Nonino, Alessandro Annarelli, Sergio Gerosa
Paola Mosca, Stefano Setti



University Press

Sapienza Università Editrice

Collana Convegni 43

Scienze e Tecnologie

Project Management

Driving Complexity
PMI® Italian Academic Workshop

edited by

Fabio Nonino, Alessandro Annarelli, Sergio Gerosa
Paola Mosca, Stefano Setti

SAPIENZA
UNIVERSITÀ EDITRICE
2018

ITALY CHAPTERS

In collaboration with the PMI® Italy Chapters.

Sapienza Università Editrice
Piazzale Aldo Moro 5 – 00185 Roma

www.editricesapienza.it
editrice.sapienza@uniroma1.it

Iscrizione Registro Operatori Comunicazione n. 11420

ISBN 978-88-9377-086-6

Pubblicato a settembre 2018

Contents

Preface

Contemporary organizations are undertaking increasingly complex projects in globalized, uncertain and dynamic environments. The proliferation of multi-organizational international programs, the emergence of new technologies, the growing sophistication of projects' scope characterized by challenging technical, time and cost requirements and the increasing number of stakeholders involved are only some of the factors that increase or generate project complexity.

During last decade, scholars and practitioners proposed different ways to deal with project complexity. Some authors support the philosophy of simplification suggesting the use of pre-established schemes, different tools and advanced skills or even the use of simplified methodologies, which require a proactive approach. Another way consists in recognizing complexity and "navigating" it, being aware of the inevitable criticalities and threats, in order to develop distinctive technical, organizational and individual capabilities for successfully driving complexity factors.

Enhancing the understanding of what project complexity is, and delineating the technical, environmental, and organizational attributes of projects that increase or generate complexity can be a fundamental step towards the identification of drivers that cause complexity and unexpected consequences for project management performance.

Since 2014, the Project Management Institute (PMI®), in the book Navigating Complexity: A Practice Guide, formally recognized the fundamental issue of managing complex projects by exploring the elements that underlie their complexity and suggesting some practical solutions to respond to the challenges of project complexity. Furthermore, recently the PMI has updated its body of knowledge to the sixth edition highlighting competencies required by project management practitioners to manage complex projects.

Therefore, the objective of the PMI® Italian Academic Workshop has been to address the topic of project complexity through a cooperation between industry's experience and academics' rigorousness towards the goal of a more in-depth understanding of this challenging phenomenon.

Fabio Nonino

Introduction

The PMI® Italian Academic Workshop, organized in 20-21 September 2018 by Sapienza University of Rome and the three Italian Chapter of the Project Management Institute, has been an event aimed at supporting participants to develop their researches to a further stage through in-depth discussions on the topic of project complexity.

This book gathers the extended abstracts of all the researches presented during the workshop. The Section 1, *PM(BOK) theory evolution*, contains the synthesis of researches developed a thorough investigation of the evolution of Project Management theory, as it emerges from the analysis of Project Management Body of Knowledge (PMBOK®), edited by the PMI®. Research anstracts contained in Section 2 developed the topic *Teaching and learning Project Management competences*, while Sections 3 and 4 deal with *Innovative trends in Project Management* and *Organizational learning for driving Complexity*, respectively.

The study of Complexity in different contexts, such as Project, Program and Portfolio, is the connecting theme among works in Section 5, named *Portfolio, Program and Project Complexity*.

The last sections have a more practice-oriented focus, indeed Section 6 deals with *Modelling and assessing complex projects*, and related contributions focus on analyses of management effectiveness and performance, Formal Requirement Models, Agent-Based Simulation, and Building Information Model.

In Section 7, the focus switches toward *Managing risk and resilience of complex projects*, while researches in Section 8 (*Complexity of project values assessment*) deal with the assessment of projects' value.

PART I

PM(BOK) THEORY EVOLUTION

1. Unveiling the complexity of PMBOK through process network analysis

Alessandro Annarelli, Cinzia Battistella, Fabio Nonino, Giulia Palombi

Project Management (PM) became an increasingly consolidated discipline for managing activities of considerable economic importance and growth in almost all organizations across different sectors, industries and countries (Turner et al., 2010; Winter et al., 2006). Moreover, PM has been also receiving a considerable amount of research starting from the 1980s and the trends are likely to continue in the future (Kwak and Anbari, 2009). Nevertheless, it is one of the most recent managerial disciplines as the first PM methodologies appeared in 1930s, but only starting from the end of the 1950s the management of engineering projects would lead to standardized tools, practices and roles, and the emergence of effective models (Garel, 2013). PM discipline includes many best practices developed and experienced by practitioners and formalized by scholars during time, also coming from different management fields, above all Operations Management (OM). In particular, mutual influence historically came from several project typologies, e.g. re-engineering business processes, developing new product and services, and improving operations quality.

Going further, discipline evolved through years, and its advancement can be represented by the progression of the standardized best practices organized in knowledge areas (KAs) and processes inside the book "Project Management Body of Knowledge" (PMBOK) developed and edited for the sixth time in 2017 by Project Management Institute (PMI), world's leading organization in PM.

The aim of the present research can be synthetized by the following research questions:

- How is the PM theory evolving?
- How did best practices, processes and knowledge areas change through time?
- Which are the most important best practices, processes and knowledge areas in PM theory?

Design/methodology/approach

We consider the PMBOK, initially published in 1996, and updated in 2000, 2004, 2008, 2013 and, most recently, in 2017, as representative of the evolution of PM best practices through the years. Each update brought a progress and enlargement of contents, organized in processes belongings to specific groups and knowledge areas. In order to define the most important processes in PM theory (according to PMI), we employed methods and indicators from Social Network Analysis. We analyzed all the PM processes described in the six editions of PMBOK and considered them as nodes of an oriented network, with incoming and outcoming links showing, respectively, previous and following project processes. Then, we constructed and organized data in adjacency matrices, where rows and columns reported the names of each process and values in the cells indicate the presence of at least a link among the processes.

Among network measures, five different typologies of centrality allowed us to analyze and understand processes' role and importance: out-degree centrality, in-degree centrality, out-closeness, in-closeness and flow betweenness. Starting from the six adjacency matrices, we calculated the value of the five centralities for all the processes and analyzed the processes and linked best practices with the highest degrees as having a key role in PM practice. From the total group of central processes identified, we selected the five processes with the highest value for each index calculated obtaining a set of almost 25 central processes (some processes appeared in the "top-five" for more than one index) for each edition of the PMBOK. Following, we listed for each process the associated best practice, i.e. a tool/technique, as reported in the corresponding PMBOK's edition, and then we took trace of the edition first reporting each tool/technique. So, we could understand when a single process with associated practice became central for PM discipline and, further, we could make an estimate of how much time it took to a single tool/technique to become central after its introduction in the standard. Moreover, we linked the processes and/or tool/technique with a management area (e.g. Purchasing Strategy/Management, Agile, Lean, TQM...) searching literature evidences about year and management field of first appearance in order to understand if PM has been influenced or produced new practices.

Findings

The results showed how the importance of specific processes changed trough time and allowed us identify PM practices, new or borrowed, that contributed to PM evolution.

The processes that for each PMBOK edition are in the top five central ones for at least two centrality measures are:

- First edition: Performance Reporting and Overall Change Control linked respectively to the KAs Project Communication Management and Project Integration Management;
- Second edition: Communication Planning and Integrated Change Control related to Project Communication Management and Project Integration Management KAs;
- Third edition: Develop Project Management Plan, Direct and Manage Project Execution, Integrated Change Control and Plan Purchase and Acquisition, all belonging to the KA of Project Integration Management except for the last one belonging to Project Procurement Management KA;
- Fourth edition: Develop Project Management Plan, Identify Risks and Collect Requirements related to Project Integration Management, Project Risk Management and Project Scope Management;
- Fifth edition: Develop Project Management Plan, Conduct Procurements and Collect Requirements associated to Project Integration Management, Project Procurement Management and Project Scope Management;
- Sixth edition: Conduct Procurement, which confirms the emerging importance of Project Procurement Management.

Originality/value

This research sets out a key contribution to PM theory. Thanks to the employed methodology, we mapped and formally analyzed the evolution of PM theory and practice.

We found evidence of chronological influence, in terms of borrowed models and practices, of Manufacturing and Technology Management, New Product Development models, Total Quality Management, and recent role of Lean Management in depicting future trend of PM models.

Research limitations/implications

Even if this research provides an important contribution to the study and understanding of how PM theory and practice evolved, some limitations must be acknowledged.

First of all, the joint consideration of all measures of Centrality might have introduced some bias in the evaluation of results: to overcome this aspect, future research should consider separately the five Centrality indexes, so as to highlight more precisely the contribution of most relevant processes and the evolution of their role, as emerging from the PMBOK.

Secondly, this study employed the PMBOK as a proxy for PM theory and practice evolution: nevertheless, we have to acknowledge that this source provides only a single view over PM theory. Indeed future studies should consider other sources, to have a more complete and holistic view over the evolution of PM theory and practice.

References

Garel, G., (2013), "A history of project management models: From pre-models to the standard models", *International Journal of Project Management*, Vol. 31, pp. 663–669.

Kwak, Y. H, and. Anbari F.T. (2009) "Analyzing project management research: Perspectives from top management journals." International Journal of Project Management Vol. 27 (5), pp. 435-446

Project Management Institute (1996-2017), "A guide to the project management body of knowledge (PMBOK guide 1st to 6th Edition), *Newtown Square, Pa: Project Management Institute*.

Turner, R., Huemann, M., Anbari, F.T., Bredillet, (2010), Perspectives on Projects, Routledge, London.

Winter, M., Smith, C., Morris, P., Cicmil, S., (2006), Directions for future research in project management: the main findings of a UK government funded research network, *International Journal of Project Management*, Vol. 24, pp. 638–649.

2. The PMBOK standard evolution: leading the rising complexity

Marco Arcuri, Cristina Simone, Antonio La Sala

The aim of this work is to enlighten how the Standard for Project Management (part II of PMBOK® Guide) has evolved over the last 30 years as it has introjected the perspective of complexity. The several contexts (private firms, public institutions etc.) in which Project Management is applied become more and more complex (i.e. uncertain and characterized by unpredictable feedbacks among their own variables and their environments). This needs an enrichment (and perhaps a new conceptualization) of the endowment of information variety provided by the Standard for Project Management with respect to the specific requisite variety asked at a local level (i.e. the specific organi-zational contexts), to lead a project with efficiency, effectiveness and sustainability.

The traditional Standard for Project Management can no longer be considered as a "comfort zone" (i.e. a set of established and "familiar" frameworks, rules and tools aiming to ensure certain and predictable results). On the contrary, the Standard for Project Management should shift towards an open standard, that is able to consistently co-evolve with the increasingly complex contexts that even more ask for new tools, creative solutions and original combinations between exploitative and explorative knowledge.

Design/methodology/approach

Through a deep and accurate content analysis, the paper analyzes the versions of the Standard for Project Management published in the last 30 years (from 1987 to 2017) together with the Practice Guide

Navigating complexity (2014), to highlight the progressive and systematic introjection of concepts, frameworks and methods provided by the complexity perspective.

Findings

In recent years, Project Management has been profoundly influenced by the complexity perspective, absorbing its concepts, principles and methodologies. This led to the abandonment of the traditional waterfall approach, reductionist and sequential, and to the adoption of the *Complex Project Management*, characterized by iterativity, incrementality, adaptability and contextualization.

The paper highlights how urgent requirements for Project Management will be:

1. continuous enrichment with respect to intellectual, methodological and creative solicitations that may arise from the perspective of complexity;
2. integration and harmonization among the different standards to promote a consistent framework;
3. tailoring at the local level: project management must increasingly present itself as a meta-platform knowledge, whose modules should be selected, adapted and combined according to the variety and variability of each specific local context (contextualization).

Originality/value

The originality of the paper mostly lies in the conceptualization of the Standard for Project Management, conceived as a provider of a huge, precious and evolutive endowment of information variety. This conceptualization leads to focus the attention on the level of fit between the exploitable information variety provided by the Standard for Project Management and the specific requisite variety needed at a local level to successfully manage the project. In so doing, the proposed conceptualization promotes helpful reflections also on the potential gap between the information variety provided by Standard for Project Management and the requisite variety asked by the local needs that, in turn, promote new solutions enriching the Standard for Project Management information variety endowment.

Moreover, adopting the perspective of complexity leads to original implications in the way to conceive a project itself. Each project can be viewed as a CAS (Complex Adaptive System), i.e. a reticular, open system whose components operate in parallel and with non-linear interactions. This highlights that a project co-evolves as a system that self-organizes and learns from the experience of positive and negative feedbacks. Considering a project as a CAS focuses the attention on the requisite variety to effectively lead a project: in an original way, the paper highlights how the requisite variety to lead a project will have to be provided by the project manager according to a tailor-made approach, creating original and emerging connections and combinations among modules of knowledge that heterogeneous standards make available.

Practical implications

The world of projects will be characterized by ever greater context variability and by a growing variability of the scope, the requirements and the constraints to be respected. This will create an ever-increasing need to improve the capability in leading complexity. Trying to provide a useful framework for project managers, the paper presents an original matrix that crosses critical organizational dimensions and the related challenges of Project Management in complex contexts (see summarized version below).

Tab. 2.1. Critical organizational dimensions and challenges for project managers in leading complexity

Critical organizational dimension	Challenges for project managers in leading complexity
Functional integration and coordination	Increasing need for bridge capabilities
HRM	Increasing need for neghentropic human resources.
Relationship among vertical and horizontal dimension	Increasing stress on the horizontal organizational dimension
Quality management	Ensuring quality in a service society.

Relationship among managerial and entrepreneurial function	Ask for an entrepreneurial role of project manager
Learning	Increasing need to "learn to learn"

Research limitations/implications

This research exclusively focuses on the PMI Standard for Project Management (part II of PMBOK® Guide); in fact, the analysis carried out did not consider additional international standards, such as the IPMA Individual Competence Baseline or the PRojects IN Controlled Environments (PRINCE2). To this end, future researches could be aimed at developing a comparative analysis to evaluate how each standard enriches itself introjecting the complexity perspective. Moreover, future researches may also be aimed at evaluating and measuring the fit between the level of complexity of one specific project and the (relatively) most appropriate standard to lead it.

References

Archibald R.D. (1985), *Project Management. La gestione di progetti e programmi complessi,* (ed. it.), Franco Angeli, Milano.

Arcuri M., (2017), *Project Management: conoscenze, abilità e soft skill secondo le norme UNI ISO 21500 e UNI 11648*, Tangram Edizioni Scientifiche Trento, ISBN: 9788864581699.

Ashby W.R. (1985), *Requisite variety, and its implications for the control of complex systems*, Cybernetica, ISSN 0011-4227, 1(2).

Barile S., Saviano M., Simone C. (2015), *"Service economy, knowledge, and the need for T-shaped innovators"*. World Wide Web, 18(4), 1177.

Bassi A. Tagliafico M. (2010), *Project Manager al lavoro: strumenti e tecniche,* Franco Angeli.

Bianchi F., Shimizu T., Koudate A., Kondo S., Masut L. (1996), *Dall'idea al cliente: come sviluppare nuovi prodotti in minor tempo con le tecniche dell'high speed management*, Il Sole-24Ore libri, Milano.

Calabrese M., Simone C., Magliocca P. (2016), *"Going Away From the "Protocol Culture": Innovation, Complexity and the Need for a Culture of Variety"*, China-USA Business Review, April 2016, Vol. 15, No.

4, 194-204.

Damiani M. (2011), *La gestione della complessità nei progetti*, Franco Angeli.

Faggioni F., Simone C. (2009), *Le declinazioni della complessità. Ordine, caos e sistemi complessi*, Sinergie, n. 79.

Folador M. (2014*), Un'impresa possibile. Persone e aziende che costruiscono il futuro,* Guerini Next.

Folador M. (2017), *Storie di ordinaria economia. L'organizzazione (quasi) perfetta nel racconto dei protagonisti*, Guerini Next.

Gambel E.L. (2010), *Management & organizzazione, Franco Angeli*, Milano.

Kerzner H. (2005), *Project Management. Pianificazione, scheduling e controllo dei progetti*, (ed. it.), Hoepli.

Manzoni P. (1998), *Multi Project Management*, Franco Angeli, Milano.

Marino A., Posati M. (2008), *Nuove tecniche per progetti estremi. La gestione sostenibile dei progetti complessi*, Franco Angeli, Milano.

Miscia S. (1997), in *"Introduzione" a Archibald R.D., Project Management. La gestione di progetti e programmi complessi*, (ed. it.), Franco Angeli, Milano.

PMI (2004), *Guida al Project Management Body Of Knowledge (Guida al PMBOK)*, terza edizione (ed. it.).

PMI (1996), *A guide to the Project Management Body Of Knowledge (PMBOK Guide)*, second edition (ed. eng.).

3. Towards Dissecting Start Up Complexity: a Project Management Point of View

Maria Teresa Baldassarre, Vita Santa Barletta, Danilo Caivano

The purpose of this paper is to dissect complexity of start-ups from a Project Management (PM) point of view in order to understand why 90% (Valis, 2014) of Start-ups fail and how PM can contribute to reduce this failure rate.

Literature provides several definitions of startup. According to Ries (2011), a startup is a human institution designed to create a new product/service under conditions of extreme uncertainty. Similarly, Blank describes a startup as a temporary organization that creates innovative products with no prior operating history, that seeks a scalable, repeatable, and profitable business model, and therefore aims to grow (Black and Dorf, 2012). Peter Thiel the founder of Paypal, says that a startup has to be unique in order to be successful (Thiel and Masters, 2014). Thus one of the critical differences is that while existing companies execute a business model, start-ups look for one and deliver a unique product/service in an extremely changing and risky environment.

If we look into these definitions and analyse the concepts they undertake, such as temporariness, uniqueness, risk, a clear recall to the definition of Project as "a temporary endeavor undertaken to create a unique product, service, or result" (PMI, 2017) appears. PM involves the use of well-identified and codified processes and a project failure/success may be assumed as the result of their (mis/correct) use.

This work assumes that a startup can be seen as a very risky project and that failure and success factors can be seen and managed as a "risks", i.e. as threats or opportunities respectively.

Risk depends on probability and impact (Risk = P x I). It is formally an uncertain event or condition that, if occurs, has a positive or negative effect on one or more startup project objectives. Thus it is in some way related to the concept of uncertainty, in other words to the probability (P) that the event occurs. If the case, it will produce an effect or consequence that will lead to an impact (I) on the achievement of one or more goals. The impact (I) can either be positive or negative for the project development. As so, we refer to opportunities and benefits or to threats and costs.

The work aims to address the following Research Goal:

Identify Project Management Processes with the aim of evaluating their influence on Startup failure/success Factors from a Project Management point of view in the context of a Startup.

Design/methodology/approach

The research implies the characterization of a start-up project, the identification of the success/failure factors, as well as good and bad practices that impact a start-up project. The research carried out has been organized according to the steps in Figure 3.1. **Errore. L'origine riferimento non è stata trovata.**

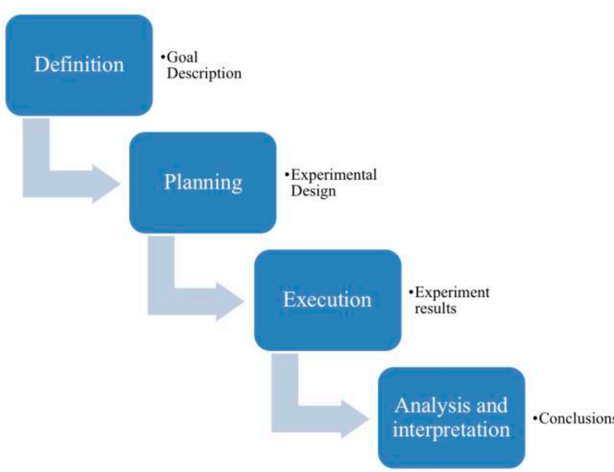


Fig. 3.1. Methodology

- Definition: in this step we identified the research goal mentioned above and further refined it in terms of the following research questions:
  - *RQ1* - What are the success/failure factors, i.e. the opportunities/problems, that influence a Start-up Project results?
  - *RQ2* - What are the Project Management Processes potentially involved in a Start-up Project?
  - *RQ3* - What are the Project Management Processes that strongly influence the Start-up Project results?

where “Influence” means that the process execution may increase or decrease the probability P or the impact I involved in a risk management activity and thus, increase or decrease the probability or the impact related to a success/failure Factor.

- Planning: The aims of this step was to identify the experimental variables, define the experiment design, select the subjects involved in the study and prepare the experimental materials needed for supporting the execution phase. More precisely:
  - *Experimental Variables Identification*. The relevant variables that characterize the phenomena under study need to be identified. In the context of this work they were identified through a literature review aimed to finding out the Success/Failure Factors that influence Start-Up Projects on one hand, and the Project Management Processes potentially involved.
  - *Experiment Design*: here the goal was to identify the right schema to use in order to correctly investigate the phenomena under study. The adopted schema was a mix method research strategy involving a qualitative explorative study (Merriam and Tisdale, 2015; Seaman, 2008; Kitchenham et al., 2015) through structured interviews and focus groups (Kontio et al., 2008).
  - *Selection of the experimental sample*. For the selection of the experimental sample “Convenience sampling” was used, a specific type of non-probability sampling method based on data collected from population members (Wohlin et al., 2012). The subjects were selected mainly because they were easiest to re-

cruit for the study in comparison to testing the entire population that would have been too large and therefore impossible to include everyone. In the study 10 project managers were identified and included in the sample. Of them 7 were PMP certified. Based on the indications outlined in ministerial decree of 18th April 2005 by Ministry of Economic Development, 2 of them work in a large company, 2 in a medium company, 2 in a small company and the rest in micro companies.

- *Experimental Instrumentation (material)*. In order to support data collection during interviews and focus groups, as well as data analysis, we created a set of excel tables, for various purposes:
    - one "Interview Table" (Figure 3.2.) for each PM included in the experimental sample. A selected cell (i,j) in the table means that the PM Process *i* influences factor *j* in the same way. The motivation for the answer was also collected.

	Factor 1		Factor 2		Factor 3		...		Factor 30	
		Comment		Comment		Comment		Comment		Comment
Process 1	☐		☐		☐		☐		☐	
Process 2	☐		☐		☐		☐		☐	
Process 3	☐		☐		☐		☐		☐	
...	☐		☐		☐		☐		☐	
Process 47	☐		☐		☐		☐		☐	

Fig. 3.2. Interview Table

- one contingency matrix (Figure 3.3.) for data consolidation and analysis, where a cell (i,j) contains the number of experimental subjects indicating that the PM Process *i* has influence on the corresponding factor *j*.

Fig. 3.3. Example of Contingency matrix

- Execution: During the execution phase each project manager included in the sample was interviewed and the corresponding *Interview Table* filled in. An empty cell means that the corresponding process/factor are neutral to each other. All the data were consolidated within the contingency table and further used within the two focus groups in order to guide the discussion and the analysis of the results. In the first focus group the results observed in the contingency table concerning to the Success Factor were discussed while in the second one only the ones related to Failure Factors were taken into account.

- Analysis and interpretation: after having interviewed the experts and consolidated the data in the contingency table, the cells of the table were colored according to the following criteria:
  - In Green the cells containing a value ranging from 10 to 8;
  - In Orange the cells containing a value ranging from 7 to 5;
  - In Red the cells containing a value ranging from 4 to 0;

The Green and Red cells were not discussed during the focus groups in that the first were immediately assumed to be reliable results while the latter were discarded as non-relevant. This criterion was adopted for both focus groups, reducing the discussion time, pushing towards stronger results. Only the "influence" related to the orange cells were analyzed and discussed during focus groups. At the end of this step we outlined a clear picture of the influence between factors and processes.

Findings

The study is ongoing and thus we cannot provide all the expected results but only the following ones that will be presented according to the research questions faced:

- RQ1 - What are the success/failure factors, i.e. the opportunities/problems, that influence Start-up Project results?
    - Answer: 9 success factors (opportunities) and 21 failure factors (threats) were found (Watson et al., 1998; Crowne, 2002; Abrahamsson, 2015). They are listed in the following Table.

Tab. 3.1. Success and failure factors of the start-up

Success	Failure
S1: Knowledge domain S2: Business Model + Market Orientation + Business Strategy S3: Innovative, feasible and scalable data S4: Team Composition S5: Acquisition of clients S6: Investigating investors S7: Moderating project volatility S8: Timing S9: Customer benefits	F1: Market need not satisfied F2: Saturated market F3: Lack of a business model F4: Customer base unknown F5: No strategic plan or business plan F6: Unknown hardware and software platforms F7: High uncertainty F8: No product introduction process F9: Development team without experience or skill F10: The product does not have an owner F11: Provision of services that delay development F12: Cost/price problems F13: Addition of new platforms (Hw and/or Sw) or resources without clear

Success	Failure
	costs F14: Lack of liquidity (not initial) F15: Conflicts between executive and founder F16: Customer not taken into consideration F17: Changes and variability F18: Product incorrectly developed F19: Unreliability of the product F20: The product is not user-friendly F21: No process for product introduction (Production Introduction)

- RQ2 - What are the Project Management Processes involved in a Start-up Project?
  - Answer: 47 Project Management Processes were identified and classified in 10 knowledge Areas according to the PMBOK 5 ed. classification (PMI, 2014) showed in Figure 3.4. Another point in favor in using PMBOK approach is that for every process the input and output needed are clearly reported together with the set of tools and techniques that can be used for supporting process execution.

Knowledge Areas	Project Management Process Groups				
	Initiating Process Group	Planning Process Group	Executing Process Group	Monitoring and Controlling Process Group	Closing Process Group
4. Project Integration Management	4.1 Develop Project Charter	4.2 Develop Project Management Plan	4.3 Direct and Manage Project Work	4.4 Monitor and Control Project Work 4.5 Perform Integrated Change Control	4.6 Close Project or Phase
5. Project Scope Management		5.1 Plan Scope Management 5.2 Collect Requirements 5.3 Define Scope 5.4 Create WBS		5.5 Validate Scope 5.6 Control Scope	
6. Project Time Management		6.1 Plan Schedule Management 6.2 Define Activities 6.3 Sequence Activities 6.4 Estimate Activity Resources 6.5 Estimate Activity Durations 6.6 Develop Schedule		6.7 Control Schedule	
7. Project Cost Management		7.1 Plan Cost Management 7.2 Estimate Costs 7.3 Determine Budget		7.4 Control Costs	
8. Project Quality Management		8.1 Plan Quality Management	8.2 Perform Quality Assurance	8.3 Control Quality	
9. Project Human Resource Management		9.1 Plan Human Resource Management	9.2 Acquire Project Team 9.3 Develop Project Team 9.4 Manage Project Team		
10. Project Communications Management		10.1 Plan Communications Management	10.2 Manage Communications	10.3 Control Communications	
11. Project Risk Management		11.1 Plan Risk Management 11.2 Identify Risks 11.3 Perform Qualitative Risk Analysis 11.4 Perform Quantitative Risk Analysis 11.5 Plan Risk Responses		11.6 Control Risks	
12. Project Procurement Management		12.1 Plan Procurement Management	12.2 Conduct Procurements	12.3 Control Procurements	12.4 Close Procurements
13. Project Stakeholder Management	13.1 Identify Stakeholders	13.2 Plan Stakeholder Management	13.3 Manage Stakeholder Engagement	13.4 Control Stakeholder Engagement	

Fig. 3.4. PMBOK Matrix

- RQ3 - What are the Project Management Processes that strongly influence the Start-up Project results?
- Answer: The early stages of the research highlighted the threats and opportunities within a start-up. This led to mapping these factors within the knowledge areas and process groups of the PMBOK matrix (PMI, 2014). What we expect to obtain, just to provide an example, is sketched in Figure 3.5.

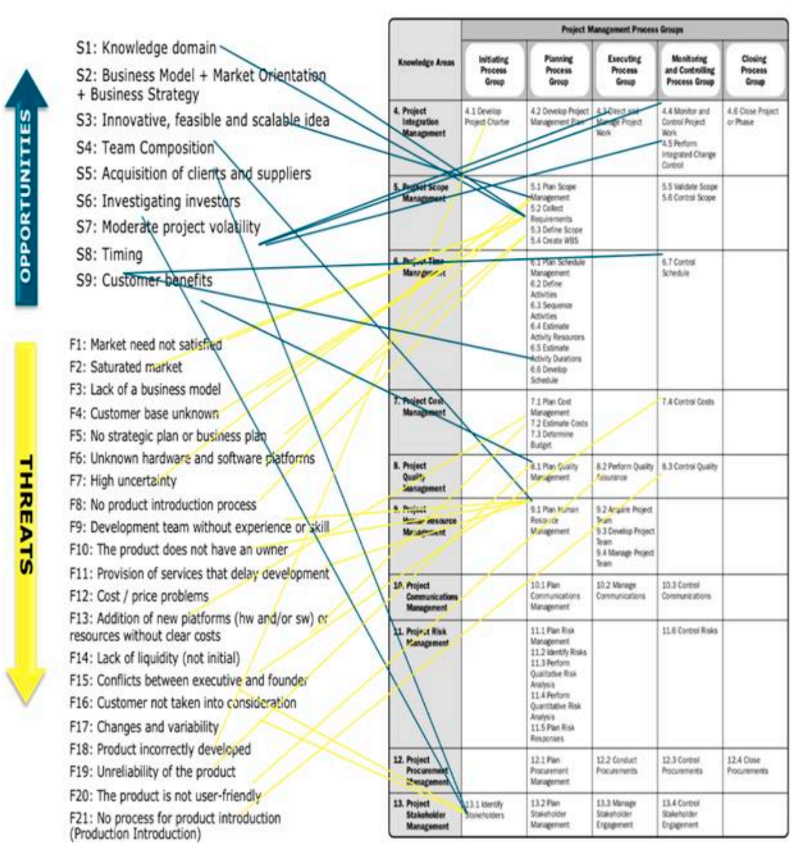


Fig. 3.5. PM Processes and their influences on failure and success factors

Originality/value

According to the authors knowledge there are no previous studies that specifically address the problems faced in this work starting from the assumption that StartUp = Project. Furthermore, we think that the results that will be obtained may be of great value for startuppers, managers and for the entire project management community.

Practical implications

The need for a start-up to release the product on the market quickly runs against to the need to maximize and optimize management processes (Sutton, 2000). However, a Startup is often not big enough and mature for adopting a structured Project Management approach. Thus a less complex and agile approach made of essential processes is needed as well as effective managerial practices, tools and techniques. The results of the present work, at the end of the ongoing experimental study, will be made up of a selection of processes, tools and techniques for addressing startup risk and complexity in an effective and sustainable way and thus to enhance any startup's project management capabilities and reduce failure and mortality.

Research limitations/implications

There are probably several threats to validity considering that this is a first high level exploratory study. Among others the following can be relevant for the expected outcomes. First of all it starts from the assumption that StartUp = Project and thus, if the assumption falls the approach will not work.

Another aspect is related to the use of convenience sampling that is relatively easy to use and inexpensive, compared to other methods, but it cuts out a large part of the population. As a result, this may leads to several issues:

- An inability to generalize the results of the study to the population as a whole.
- The possibility of under or over representation of the population.
- Biased results, due to the reasons why some people choose to take part and some don't.

Therefore, the main limitations of the research are related to the experimental sample taken into consideration, because 10 project managers represent a very small part of the community. However this sample has allowed us to start the discussion about this research idea and lay the foundations for future work.

References

Abrahamsson P., (2015). Key Challenges in Early-Stage Software Startups. *Agile Processes, in Software Engineering, and Extreme Programming: 16th International Conference*, Helsinki, Finland, May 25-

29, 2015, Proceedings. Vol. 212. Springer. p. 52.

Blank S. and Dorf B. (2012), *The Startup Owner's Manual: The Step-By-Step Guide for Building a Great Company*, K & S Ranch.

Crowne, M. (2002). Why software product startups fail and what to do about it. Evolution of software product development in startup companies. In *Engineering Management Conference, 2002. IEMC'02. 2002 IEEE International* (Vol. 1, pp. 338-343). IEEE.

Decreto Ministeriale 18 Aprile 2005 – Ministero dello Sviluppo Economico. http://www.sviluppoeconomico.gov.it/images/stories/d.m.-18-aprile-2005.pdf

Kitchenham, B. A., Budgen, D., & Brereton, P. (2015). *Evidence-based software engineering and systematic reviews* (Vol. 4). CRC Press. (chapter 19).

Kontio J., Bragge J., Lehtola L. (2008). The Focus Group Method as an Empirical Tool in Software Engineering. In: Shull F., Singer J., Sjøberg D.I.K. (eds) *Guide to Advanced Empirical Software Engineering.* Springer, London

Merriam S. B., Tisdell E. J. (2015), *Qualitative Research: A Guide to Design and Implementation*, Chapter 2.

Mia Valis, The Top 20 reasons startups fail, CB Insights (2014), available at https://thenextweb.com/insider/2014/09/25/top-20-reasons-startups-fail-report/.

Peter Thiel and Blake Masters. (2014), *Zero to one: Notes on Startups, or How to build the future*. ISBN 978-0804139298.

Project Management Institute PMI (2014). *A Guide to the Project Management Book of Knowledge: PMBOK Guide* (5th edn). Pennsylvania, USA. ISBN 978-1-62825-004-6.

Ries E. (2011), *The lean startup: How today's entrepreneurs use continuous innovation to create radically successful businesses*. Crown Books.

Seaman C. B. (2008). Qualitative Methods. In: Shull F., Singer J., Sjøberg D.I.K. (eds) *Guide to Advanced Empirical Software Engineering*. Springer, London.

Sutton S. M. (2000), The role of process in software start-up. In: IEEE Software 17.4 pp. 33-39.

Watson, K., Hogarth-Scott, S., & Wilson, N. (1998). Small business start-ups: success factors and support implications. *International Journal of Entrepreneurial Behavior & Research*, *4*(3), 217-238.

Wohlin, C., Runeson, P., Höst, M., Ohlsson, M. C., Regnell, B., & Wesslén, A. (2012). *Experimentation in software engineering*. Springer Science & Business Media.

PART II

TEACHING AND LEARNING PROJECT MANAGEMENT COMPETENCES

4. Teaching technical and behavioural competences in project management

Matteo Kalchschmidt, Tommaso Buganza

Managing projects is a complex issue and it implies leveraging on dif-ferent competences (Dainty et al., 2005). "Good" Project Management is achieved by leveraging properly on both technical and behavioural competences (Hodgson et al., 2011; Tabassi et al., 2012). However, frequently training programs tend to consider these as separated competences. "PM based" training programs address only technical competences focusing only on organizational issues but not on people management. Moreover, PMs tend to go through some basic and ge-neric training programs on behavioural skills. However, there is a missing link between the two groups of competences.

We argue that addressing simultaneously and coherently both kinds of competences may pay off.

This research is related to a massive training program conducted by an Italian Multinational Group that involved during 2008, 2009, 2010 and 2011 more than 700 Project Managers. Based on data collected during the development of this program, we aim at testing whether teaching both technical and behavioural competences simultaneously and jointly can improve the training experience and effectiveness.

Design/methodology/approach

To do so we compare two training courses: "Full" course focused only on technical competences; "Systemic" course focused on both technical and behavioural competences.

For a general list of competences included in the course please refer to Table 4.1.

Data was collected for 19 editions of the Systemic course including 454 participants and 13 editions of the Full one, including 263 participants. Table 4.2 highlights key figures of the two courses.

Tab. 4.1. List of competences included in the courses

Technical competences	Behavioural competences
• Integration Management • Scope Management • Time Management • Cost Management • Quality Management • HR Management • Risk Management • Procurement Management	• Leadership • Communication Management • Team Management • Conflict Management • Negotiation • Systemic Thinking • Problem Solving • Decision Making

Tab. 4.2. Key characteristics of the two considered courses

	"Full"	"Systemic"
Total Duration	5 days: 44 h	5 days: 54 h
H. technical competences	38 h (86%)	22 h (41%)
H. behavioural competences	0 h	12 h (22%)
H. "blended"	0 h	14 h (26%)
Other activites	6 h (14%)	6 h (11%)
Simulations	12 h	15 h
Residential course	Yes	Yes

For each edition we were able to evaluate:

- The initial competences of participants, by means of a multiple choice test covering all different knowledge areas, focused only on technical competences, and fulfilled before the course start (a Knowledge Based Test – KBT)
- The gained competences of participants acquired during the course, by means of a multiple choice test covering all different

knowledge areas, focused only on technical competences, and fulfilled at the end of the course start (a Learning Verification Test – LVT).

- The participants' satisfaction of the course assessed by a questionnaire to assess the general appreciation of the course.

Table 4.3 summarises key statistics about the two courses.

Tab. 4.3 Key results of the statistical analysis

		Full	Systemic
KBT	Average	0.60	0.60
LVT	Average	0.86	0.85
Evaluation		4.86*	5.15*

(* difference with sig < 0.001)

Analyses were conducted by means of ANOVA and Multiple Regression Analysis.

Attendees are mainly operating as Project Managers, have an average age of 40 years old with an average experience in PM role equal to 6 years. The vast majority have a "technical" background coming from engineering areas. Groups attending the two courses are similar in terms of initial competences thus allowing to compare the results in terms of learning.

Findings

The analysis provide clear evidence that teaching jointly technical and behavioural skills is extremely powerful. In particular, technical competences appear improved after both courses and the extend of improvement is not statistically different between the two courses.

However, the satisfaction in the Systemic course (i.e. thus including both behavioural and technical competences) is significantly higher compared to the Full course. Moreover, the detailed analysis of the different factors that contribute to the general satisfaction of the two courses shows that these differ among the two learning experiences.

This result suggests to companies willing to improve effectively the PM competences of their executives, to address also behavioural competences and foster the interconnection between technical and behavioural capabilities.

Originality/value

These results show that the two courses are both effective in increasing technical competences, but that reducing focus on technical competences in favour of behavioural ones is not harming the learning results. In addition, participants satisfaction is significantly higher when behavioural and technical competences are blended.

Research limitations/implications

The paper is not free from limitations. In particular, the identified relationship may partially depend on the organizational contexts in which learners operate. We think that this issue can be under control since the 700 managers belong to different business units of the same industrial group, thus suggesting that some commonalities are there.

Second, even if we controlled regression results by considering some exogenous factor, still participants' specific factors have not been considered, since the satisfaction analysis was anonymous thus limiting the traceability of respondents.

References

Dainty A.R.J., Cheng M., Moore D.R. (2005), "Competency-Based Model for Predicting Construction Project Managers' Performance", *Journal of Management in Engineering*, Vol. 21, No. 1, pp. 2-9.

Hodgson D., Paton S., Cicmil S. (2011), "Great expectations and hard times: The paradoxical experience of the engineer as project manager", *International Journal of Project Management*, Vol. 29, No. 4, 374-382.

Tabassi A.A., Ramli M., Abu Bakar A.H. (2012), "Effects of training and motivation practices on teamwork improvement and task efficiency: The case of construction firms", *International Journal of Project Management*, Vol. 30, No. 2, pp. 213-224.

5. The role of Junior Project Manager in Project Management: requirements, certifications and training opportunities

Andrea Molinari, Michele Urbani

The purpose of this paper is to shed a light on the role of Junior project manager inside organizations and the state-of-the-art of the certification processes available today. In literature, few studies can be found which systematically investigated the stimuli for employees for voluntary certification in Project Management. Nevertheless, voluntary certification in Project Management is rapidly growing, but this is mostly devoted to senior positions, or in general to a full-fledged project manager. There are indeed many reasons to pursue for a certification in Project Management, among the others the advantage when competencies of candidates for positions in highly project-centric organizations are evaluated by recruiters and managers. While projects become more complex and the need of a junior role for Project Management is evident, it becomes very difficult for workers who just entered the labor market to find an adequate training path that delivers a correspondent and recognized certification.

Nowadays, the investments in training, methodologies and certifications for Project Management are relevant, but as witnessed by different studies, the success rate of projects is still very low, and most of cultural and professional gaps still exist. Respect to the current certifications available in the Project Management domain, it seems that training processes do not adequately prepare managers to deal with the complexity of the real world, while other authors are even more critical, stating that current Project Management training tasks are not suited to prepare project managers. Some researches claim that there are very limited evidences about the efficacy of certification programs in Project Management, i.e., certified project managers are not more successful than non-certified ones. These analyses are focused on project managers, but for Junior project managers, to the authors' knowledge no analysis have been found and no specific studies on the requirements have been conducted. What surely can be noticed looking at the (many) requests from the market of a Junior project manager, the characteristics required by companies are clearly identifying a person with experience, seniority and a solid Project Management background.

Students that are passionate to Project Management, or that are interested in covering this role inside the organization where they will start to work, clearly cannot aspire to a project manager position. At the same time, they find many difficulties in getting a certification adequate to their expectations, compatible with the junior project manager role required by the organization.

In terms of Project Management tasks, the role of Junior project manager is crucial as a support to the whole team, especially for the entitled project manager. It seems that this role is mainly associated with secretarial activities, tasks with low or no relationship with the Project Management discipline, demoting the importance of the Junior project manager to a sort of secretary.

In order to refute this hypothesis, we started looking at the profile of Junior project manager as outlined by companies in their job offers, and we checked the type of professional certifications available for this emerging profession. We therefore analysed the situation of job offers in three countries with different market labour, educational system, approach to Project Management like USA, Germany and Italy. As a conclusion, we propose a selection of contents to create a specific educational path taken from the existing ones that, in our opinion, is more suitable in terms of workload, expectations of participants and expectations of companies.

Design/methodology/approach

Having the objective of understanding which characteristics are important for a Junior project manager, we followed an empirical approach, i.e., analysing the job offers for this position available in Linkedin™, and then matching these requests with the available certification paths for this profile. The considered certifications are the

PMI™ CAPM and the PRINCE2™ (Foundation & Practitioner). The analysis was conducted during January and February 2018, monitoring the job offers with keywords "Junior project manager", "Assistant project manager" and respective linguistic variations / abbreviations available in three significant countries: Italy (69 positions found), Germany (639 positions found) and USA (1149 positions found). Our attention during the analysis of the job offer contents has been on a) the industrial sector where the offer came from, b) the requirements in terms of past experience, c) if the candidate was expected to have a certification and d) the required languages.

The results have been summarized in a set of characteristics for the profile that we considered relevant, but that substantially correspond to a senior project manager. So we decided to analyse the specific contents of the certifications, cutting topics that did not correspond to what companies require.

Findings

Considering that this profile is clearly an entry point to the Project Management domain, the surprising findings of this preliminary and empirical study can be summarized as follows.

a) Companies consider the Junior project manager as a highly skilled profile, very close to the project manager in terms of characteristics, only requiring a lower level of seniority. This is not appropriate in general, thus discouraging young applicants because of responsibility burden required. In the analysed period, a non trivial number of job positions have been reopened after a first attempt (at least in our monitoring period). In short, the requirements listed below are the result of the research on LinkedIn for Junior PM positions, condensing and summarizing the various job offers' descriptions.

- Team work: ability to liaise the stakeholders and ability to interact with different departments (propensity to cross-functional knowledge).
- Ability to work independently: in addition to promote team-working, it is often required the ability to carry out independent work.

- Management of multiple projects simultaneously.
- Stress resistence.
- Pro-active approach to problems.
- Effective comunication and proved organization skills.
- A minimum technical knowledge in the firm's sector.
- Junior PM is often (but not always) required to assist a Senior PM.

b) As we can see, these requirements are contradictory, because they clearly refer to senior professionals with a solid background, but at the same time the required profiled is a junior position, with respective carrier perspective and salary.

c) To our knowledge, Universities (at least in Italy) are not providing a specific path for Junior project managers, thus leaving students with the only choice of starting to work on certification materials from the very beginning

d) The current certifications paths require a very strong effort for the candidate, with exams' contents very close to the fully-fledged project manager. For example, the CAPM™ has the same contents and the same pages to study respect to the equivalent PMP™ certification, only pre-requisites are lighter. This is another element that discourage (probably more than any other) new workers to undertake the certification process. Today, in order to acquired a CAPM™ certification, the candidate has to work hard on the 573 pages of the Project Management Body of Knowledge 6th edition, to sustain a tough 3-hours written examination with 150 questions and to have 23 hours of Project Management education. An empirical analysis we conducted on approx. 250 students of the University of Trento and of the Free University of Bolzano where we have taught a PMI-based Project Management course, revealed that none of the students have undertaken the CAPM™ certification. Even if empirical and not sustained so far by qualitative interviews, we are not surprised by this result.

e) There is a strong interest for this profile in the IT sector, especially in USA and Italy

f) Respect to language competencies, Italy and Germany are more flexibile in requesting other languages that mother tounge, while USA demonstrated no extra requests on foreign languages

Research limitations/implications

The limitations of this research are strictly related with its empirical approach, pursued by manually analysing the different job offers and extracting relevant information for the formulation of our future research. We need firstly to broaden the analysis to other social media and to traditional Human Resources service providers. These market players are clearly not very easy to analyse, but there are other channels that could be followed in order to understand what the market is intending and searching for when looking for a "Junior project manager".

The main implications of this research, in our opinion, could be a profound redefinition of educational requirements for this role. In organizations, the Junior project manager has a precise and well defined reason to exist, mainly the assistance of the project manager not in the sense of a secreterial support (whereas in many situations we found this interpretation of the role), but in the sense of a person that, even with lack of experience, is able to speak the Project Management language, is able to apply the main tools and techniques available to support the project conduction. For this, basing our study on the Project Management Body of Knowledge (PMBOK), we would suggest a revision of some chapters of the book in terms of extension of contents (chap1, 2 and 3), the preservation in toto of chapter 5,6 and 7 and some very few parts of risk management and stakeholders management. Another element is that parts of the certification which require evaluations based on experience should be avoided, and the chapters missing in the previous list should be condensed into a general introduction to "other knowledge areas".

In conclusion, in our opinion it's very important that the Project Management community takes the responsibility of stimulating a better definition of this role in order to give continuity to educational paths inside Universities where Project Management courses have been activated. After the degree, students are not finding appropriate positions in the Project Management world because they are in a sort of deadlock: a) on one side, not having the required seniority, they could not aim at becoming a full-fledged project manager, especially because certifications (like PMI PMP™) require a certified amount of certified experience; b) on the other side, the current certifications comparable to a Junior project manager (mainly PMI CAPM™) require an inappropriate effort respect to the senior positions. This, in our experience, discourages applicants to Junior project manager positions, while companies between the lines identify in this role a sort of high-level secretary, thus deleting any interest of students for this position.

References

Blomquist T., Farashah A. D., Thomas J. (2018), "Feeling good, being good and looking good: motivations for, and benefits from, Project Management certification", *International Journal of Project Management*, Vol. 36, pp. 498—511

Crawford L. (2005), "Senior management perceptions of Project Management competence", International Journal of Project Management, Vol. 23, pp. 7—16

Higgins W., Hallström K.T. (2007), "Standardization, globalization and rationalities of government.", Organization, Vol. 14, Issue 5, pp. 685–704.

Horder J. (2015), "Higher apprenticeships in England: professional and vocational Formation", International Journal of Training Research, Vol. 13, Issue 3, pp. 174--193

Starkweather J.A., Stevenson D.H. (2011), "PMP certification as a core competency: Necessary but not sufficient", Project Management Journal, Vol. 42, Issue 1, pp. 31—41

Takey S. M., de Carvalho M.M. (2015), "Competency mapping in Project Management: an action research study in an engineering company", *International Journal of Project Management,* Vol. 33, Issue 4, pp. 789—796

Thomas J., Mengel T. (2008) "Preparing project managers to deal with complexity – Advanced Project Management education", *International Journal of Project Management*, Vol. 26, Issue 3, pp. 304-315

6. Project Management and Project Complexity at Top Business Schools

Marco Sampietro, Antonio Nieto Rodriguez

Organizations perform more project compared to the past (Roland Berger, 2012) and not having the competencies to successfully manage projects can be detrimental to the current performance and to the abil-ity of the organization to succeed in the long term. As pointed out by many authors (Archibald and Archibald 2015; West 2010; Englund and Bucero 2006; Love and Love 2000; Pinto and Slevin, 1988), project success is not only influenced by Project Managers and Team Mem-bers but also from middle and top management roles who can sup-port projects activing as project sponsors or can design an organiza-tion that supports the proper management of projects. Based on this reasoning, leaders, such as managers and executives, should possess Project Management competencies. Many current and future manag-ers and executives go to learn the skills needed to lead an organiza-tion at Business Schools. In fact, Business Schools are particularly rel-evant as they are well known for creating the next generation of lead-ers and for strengthening the competencies of existing leaders. The main question is: are Business Schools teaching Project Management? And, since the complexity of business environments is increasing, are business schools teaching managing complex projects or dealing with project complexity?

Design/methodology/approach

According to AACSB International (2010) there are 12,087 Business Schools in the world. Since this number is too big and contains very heterogeneous Business Schools in term of size, quality and standing, it has been decided to focus on the most relevant ones. In the Business School sector relevancy is measured by some organizations which compare and rank them. For this research the most famous international rankings have been used to identify what we defined "Top Business Schools". In particular, the following rankings have been considered: Financial Times Open Enrolment Ranking 2016, Financial Times Global MBA Ranking 2016, Financial Times Executive MBA Ranking 2016, Financial Times Online MBA Ranking 2016, The Economist Executive MBA Ranking 2016, Bloomberg Full Time International MBA Ranking 2016. In this study, Business Schools have been considered "Top" when they were mentioned at least in one of the above mentioned rankings. In case a program is jointly delivered by more than one Business School, all the partner Business Schools have been inserted in the list.

As a result, the final list was composed of 197 Business Schools. Once the final list had been created, data had been collected by looking at the websites of all the Business Schools in order to find Project Management contents in the following programs:

- MBA;
- Online MBA;
- Executive MBA;
- Specialized Masters;
- Certificates;
- Open Executives Programs.

Data had been collected between November 2016 and February 2017.

Findings

In total the 197 Business Schools offer 379 MBAs and 35% (134) of the MBAs have Project Management contents. Normally MBAs are organized into Core and Elective courses. Elective courses are the ones chosen by a student from a number of optional subjects or courses in a curriculum, as opposed to a required (Core) course, which the student must take. By using this classification, it emerges that 8% of the Project Management courses are Core 80% are Elective (it was not possible to classify the remaining 12%). No courses have been found addressing the complexity topic.

In Online MBAs the situation is very similar: 35% offer Project Management courses and 92% of them are Elective. Again, none of them deals with the topic of complexity.

Figure in Executive MBAs are quite different since only 10% of the EMBAs include Project Management contents and, among them, 65% are Elective. Again, no references to complexity.

When considering Specialized Master, 11% of them provide Project Management courses, 5% provide entire masters focused on Project Management but 0% addressing complexity (the master closer to complexity is called Project Management of Big Projects). This low percentage is partially explained by the fact that these type of programs try to limit general management skills in order to stay focused on their specific specializations. If we use another perspective, which is the number of Business Schools offering Project Management contents among the Business Schools with Specialized Masters, figure rises to 42%.

When it comes to Certificates, 10% of the Business Schools offering Certificates provide Project Management Certificates while an additional 15% provides Project Management courses in their Certificates. None of them are related to complexity. If we consider as a unit of analysis Certificates and not Business Schools that provide them, the percentages drop to 2% and 3%. The explanation is similar to the one provided for Specialized Masters, in fact, Certificates are normally focused on very specific topics.

Finally, 23% of the Business School with Open Executive Programs offer Project Management Courses. In total the course provided are 81. Among them, two courses clearly address the topic of complexity. Their titles are: Leading Complex Projects and Programmes, Managing Complex Procurement and Projects.

Originality/value

There are no extensive studies of the diffusion of Project Management in the Business School and there is also limited debate on this topic. The aim of this research is to trigger a more intense discussion on this topic and hopefully to increase the diffusion of Project Management in the Business Schools.

Practical implications

Given the importance of Project Management to achieve positive business results, the diffusion of Project Management among the top Business Schools does not seem satisfactory. However, it seems there is a positive trend, in fact, in 2012, one of the authors of this paper conducted a similar study analysing the MBAs listed in the Financial Times Global MBA Ranking. At that time, 25% of the Business Schools had Project Management courses (both core and electives) in their MBAs while the percentage is now 35%.

In order to improve the situation, it is important to analyse the causes that lead to such a low diffusion.

A first cause might be related to competition and price. Business Schools with good standing, in fact, are very expensive and there is no shortage of offering among competitors. This can decrease the interest of the Business Schools to invest in Project Management.

A second cause could be that participants of some programs (especially MBA and EMBA) might already have Project Management skills and competencies. However, based on the authors' experience, this was the true in roughly 15 to 20% of the cases.

A third cause is based on the observation that many participants, at first, do not consider Project Management as a core skill for their career. What is the source of this belief? There are probably many reasons, one of which is particularly relevant: too often people think that Project Management is for Project Managers while in reality Project Management is a relevant skill for every person involved in project environments. The origin of this misunderstanding may also derive from the vast Project Management body of knowledge (books, articles etc.), which is almost exclusively targeted at project managers.

A fourth cause might be that Business Schools are not fully aware of the role that managers and executives play in supporting project leadership and performance. Discussions we had with some MBA and EMBA Directors suggest that they too have a tendency to relegate Project Management to operative or middle management roles. It is no coincidence that many Project Management Professors work in the Operations Department of Universities and Business Schools. Project Management is still too often considered as an engineering, IT or technical discipline, thus neglecting its managerial components and the strategic role that many projects play in transforming the organizations.

A fifth cause might be that Project Management is not very interesting for professors working in Business Schools and for this reason they do no try to push Project Management contents in the various training programs. In fact, while many topics taught at Business Schools also fit with Academic interests, Project Management is only rarely a career path in many Universities and Business Schools.

In order to increase the diffusion of Project Management, there are some actions that can be taken.

On the Business Schools side, Deans and MBA Program Directors need to understand that Project Management has become one of the most demanded skills by organizations around the world. Execution has become one of their highest strategic priorities, and it is only through project management that this can be achieved. It is necessary to provide them with a better explanation of what Project Management is really about. This paper is an attempt to work in that direction.

On the Organizations side, executives and HR departments have started to acknowledge the need to utilize Project Management competencies in all aspects of their organizations. Having project managers is not enough. Leading organizations are establishing corporate project management offices, project management training curriculums, career paths for project professionals, and requiring successful project experience of their high potential employees. The evidence is there, and our view is that this trend will only continue.

On the Knowledge side, the issue is more difficult to tackle. In fact, not all people involved in spreading Project Management wisdom and expertise have the competencies or the status to effectively target managers and executives and to make them aware that Project Management should be a core competency not only for their employees but for them as well.

On the Student side, if they want to become true leaders and have a successful career, they should carefully consider which Business School they enroll at. They should choose an MBA or Executive MBA program that includes in-depth Project Management courses.

Research limitations/implications

The main limitation of this study is related to the data collection method. In fact, data were collected from the websites of the Business Schools and unfortunately the information provided was limited.

It would be interesting to redo the same study in the next years, in order to see eventual positive trends in the diffusion of Project Management at Top Business Schools.

Finally, authors would like to acknowledge the invaluable support provided in collecting data for this research by Stefano Cavallazzi and Kannan Swamy.

References

Archibald, R. D., Archibald, S. C. (2015). Leading & Managing Innovation. What Every Executive Team Must Know about Project, Program & Portfolio Management. CRC Press.

Englund, R.L. and Bucero, A. (2006). Project Sponsorship: Achieving Management Commitment for Project Success. Jossey-Bass.

Love, A.L. and Brant-Love, J.. (2000). The Project Sponsor Guide. Project Management Institute.

Markides, C., Charitous, C. D. (2014). Competing with dual business models: A contingency approach. Academy of Management Executives, Vol. 18, No. 3, pp. 22-36.

Nieto-Rodriguez, A. (2013). Advances in Project Management Series: Evidence of the Neglect of Project Management by Senior Executives. PM World Journal, Vol. 2, No. 2.

Pinto, J. K. and Slevin, D.P. (1988). Project Success: Definitions and Measurement Techniques. Project Management Journal, Vol. 19, No.1, pp. 67–72.

Project Management Institute. Pulse of the Profession. 2016

West, D. (2010). Project Sponsorship. Gower Publishing Company.

Roland Berger (2012). Mastering Product Complexity. Roland Berger Strategy Consultants.

7. Experiencing Project Management Teaching using Business Games: the Warwick Business School Case Study

Nicola Baldissin, Simone Magrin

The growing complexity of the current competitive context requires orientating future managers' training process toward decision-making ability. A change in the traditional teaching model is required to develop learning models for current and future managers posing them at the centre of the learning process (Baldissin *et al.*, 2017). The five major learning objectives are: experience gained, strategy formulation, learning concepts, decision-making skills and teamwork (Faria *et al.*, 2009). A business game (BG) is a serious game in a business environment that can lead to one or more of the previous results (Greco *et al.*, 2013). The teaching methodology of the business game is based on experiential and active learning and the use of business games enhances the effectiveness of educational processes (Lainema and Makkonen, 2003).

We presents the results of a research focused on the analysis of learning results obtained using a Project Management Business Game (PMBG), a web-based competitive multiplayer serious game, in the case study of the Warwick Business School. We will explain the features of the PMBG and the teaching methodology adopted analysing its learning effectiveness in a live classroom simulation. Finally, our work proposes some lesson learned useful for a more effective application in the learning process.

Design/methodology/approach

The research methodology is a single descriptive case study on the experience of the Warwick Business School in adopting an innovative learning tool for enhancing the comprehension of PM concepts and methodologies.

The Project Management Business Game (PMBG) is a web-based competitive multiplayer serious game developed by The Business Game Ltd used for teaching and learning assessment. The game consists in managing a complex project of an airplane construction asking the participants to simulate the management of a project during two key phases:

1. BID (formalizing an offer in response to a Request for Proposal from a client)
2. DELIVERY (delivery and control of project activities)

Table 1 summarizes learning objective, steps of the game and skills developed.

Tab. 7.1. PMBG phases, learning objectives, steps, decisions and skills developed

PHASE	LEARNING OBJECTIVE	STEPS OF THE GAME	DECISIONS	SKILLS DEVELOPED
BID	Understanding the main principles of project planning its effect on the costs, duration and profitability.	1 RUN: 1) Analyse the Context 2) Allocate the Resources 3) Simulate* 4) Use the slack time 5) Risk Management 6) Send the Final Offer	• Plan the macro- activities • Do Make or Buy choices • Allocate the Contingencies • Determine the price • Determine the Delivery date	TECHNICAL
			• Allocate internal resources	SOFT
DELIVERY	Understanding how to manage a project execution, evaluate the status of the project and manage the requests from the customer.	3 RUN (each one to be completed in one week): 1) Read the e-mails 2) Evaluate the status of some activities 3) Simulate* 4) Evaluate the status of the Project 5) Accept/Reject the Change Requests (after testing them) 6) Crash some activities 7) Use of the slack time 8) Closing	• Re-planning • Manage the Risks • Evaluate opportunities of crashing some activities	TECHNICAL
			• Manage the project communication • Evaluate the possibility to accept a change requirements asked by the customer	SOFT

*Once the Resources have been allocated, it is possible to simulate the plan as many time as the users want in order to evaluate the impacts of the decisions made.

The PMBG has been used inside the Project Management module of the Executive MBA course organized by the Warwick Business School (WBS) in academic year 2017-2018. The game has been adopted inside two consecutive editions of the Master and involved 63 students.

Teaching methodology in the Project Management module inside the Executive MBA course

The game involved the participants during a project management classroom training lasting 3 days. The 2 phases of the game were structured in three different runs: 1 run for the bid and 2 runs for the delivery (Figure 1).

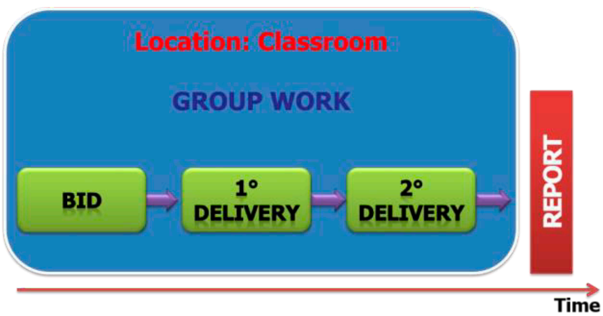


Fig. 7.1. Training methodology

Learners completed the bid and both the run of the delivery working in teams during the course (2 days for the BID and 1 day for the DELIVERY). At the end of the training process, participants received a report containing the main results of the management of the project, the final score and the overall ranking. The overall score has a value between 0 and 3000 points. The following table summarizes, for each macro-step, the maximum score and the evaluation parameters.

Tab. 7.2. Final Evaluation Structure

	Maximum Score	Evaluation Parameters
BID	**1000** points	• Final Price • Delivery Date • Milestones
DELIVERY	EXTERNAL CUSTOMER **1000** points	EXTERNAL CUSTOMER • Customer Satisfaction with reference to the Change Requests • Product Quality • Delay in the delivery
	INTERNAL CUSTOMER **1000** points	INTERNAL CUSTOMER • Preservation of the EVA defined during the BID phase • Final EVA • Final Margin

Learning process

The learning process started from a lesson and a presentation of the game. The design of the lessons considered three factors: *content, students' preparation, time*. The presentation introduced learners to the business game with a video, describing platform, scenario, model and rules of the game.

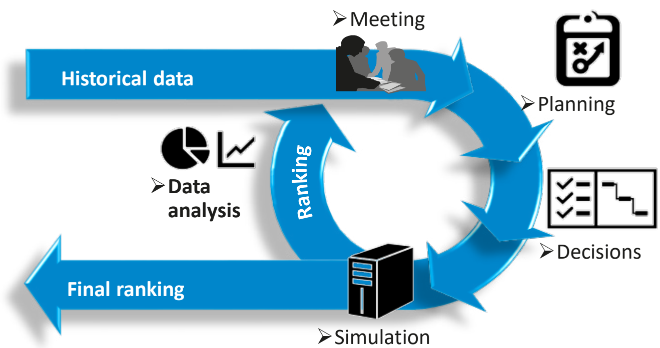


Fig. 7.2. The learning cycle

During the competition, the player experienced the fundamental steps of the learning cycle (Figure 2):

- *Meeting and planning*: teams plan the strategy;
- *Decisions*: players take game decisions within a pre-determined time period;
- Simulation: after the players/teams have entered their own decisions, the system provides results and ranking;
- *Data Analysis*: players analyse output to compare them with expected results to self-assess the correctness of the strategy.

This process is cyclical: after analysing the results, the participants take decisions for the next period. The final stage of debriefing is very important to explain the progress of the tournament to the players, highlighting the effects of the choices made during the game. As regards the PMBG, the software automatically creates a report containing a detailed analysis of the topics and related choices (Table 3). Learner finds quantitative and qualitative information on the decisions and, for each project activity, he/she sees the explanation of correct choices and his/her choices. Table below lists arguments covered.

Tab. 7.3. Topics analysed by the report of the PMBG

PHASE	TOPICS
BID	1. Evaluation of the use of mitigation 2. Evaluation of the allocation of contingency 3. Analysis of resource allocation
DELIVERY	1. Analysis of the estimated progress 2. Evaluation of the “change” choices 3. Evaluation of the use of crashing 4. Analysis of the financial results

Findings

In Figure 3, we report the results of the training in terms of learning level (measured by final score). The population is 63 persons, the average score is μ=1683 with a standard deviation of σ=523.78.

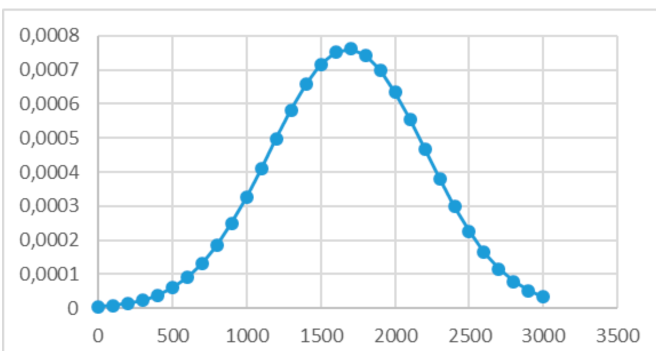


Fig. 7.3. Final score distribution

We got some evidences of impact of training on PM skills and on behavioural competences. First, the results of analysis show that learners developed decision-making skills and improved confidence in situations of risk and uncertainty. They took many risks by experimenting impact of their choices in the virtual environment. Second, the data demonstrate a great commitment of students as highlighted by the high number of refinement of strategic and operative choices before taking a decision. Third, we found evidences of increasing of their propensity for teamwork. Improvement in the learning process can come by the planning of intermediate presentations performed by students containing a strategy declaration and by adding explanatory case studies during competition phases.

Originality/value

This research sets out an innovative contribution to PM leaning and teaching methodologies.

We found evidence of the learning effectiveness of a live classroom simulation and of the good design of the teaching methodology based on the adoption of a project management business game.

Research limitations/implications

Even if this research provides an important contribution to the research stream on learning and teaching project management, the major limitation comes from the fact that results derive from a single case study. Despite this consideration, this PMBG has been designed from another case and it can be easily adapted for a wide application. Our future researches will move through two paths: the first concerns with enlargement of the sample that will allow a better generalization of the results, while the second concerns the development of a framework to quantitative evaluate the performance of individuals and teams.

References

Baldissin, N., De Toni A.F. and Nonino, F. (2017), "Experiencing Successful Training Practice using Business Games: the Finmeccanica case study", *LTSE Conference*, Bristol, 25-26 April

Faria, A.J., Hutchinson, D., Wellington W.J. and Gold S. (2009), "Developments in Business Gaming : A Review of the Past 40 Years", *Simulation & Gaming*, 40(4): 464-487.

Greco, M., Baldissin, N. and Nonino, F. (2013), "An Exploratory Taxonomy of Business Games", *Simulation & Gaming,* 44(5): 645-682.

Lainema, T. and Makkonen, P. (2003), "Applying constructivist approach to educational business games: case REALGAME", *Simulation & Gaming,* 34(1): 131-149.

PART III

INNOVATIVE TRENDS IN PROJECT MANAGEMENT

8. Fostering innovation in infrastructure projects through Public Private Partnerships

Nunzia Carbonara, Roberta Pellegrino

Recognizing the relevance of public procurement for improving public infrastructure and services, recent literature on public management focuses on the relationship between the public procurement delivery methods and innovative solutions and products (Eaton et al., 2006; Edler and Georghiou, 2007). This paper contributes to the ongoing debate concerning the role of collaborative public-private relationships in fostering innovation in public procurement. With this aim, we focus on a particular form of public procurement that relies on the collaboration between the private and the public sector, namely the public-private partnerships (PPPs). These are "agreements where public sector bodies enter into long-term contractual agreements with private sector entities for the construction or management of public sector infrastructure facilities by the private sector entity, or the provision of services by the private sector entity to the community on behalf of a public sector entity" (Grimsey and Lewis, 2002). In par-ticular, the paper aims at overcoming limitations of the existing literature on PPPs and public procurement by providing answers to the following key research questions: Which are the PPP features that favor innovation? How properly structure a PPP in order to foster innovation?

Design/methodology/approach

Drawing upon the main streams of studies on innovation, we elaborate a conceptual framework that identifies the PPP factors that foster innovation. To do this, we analyze the PPP by breaking it down into four main dimensions: the arrangement structure, the industry structure, the contract structure, and the network structure. For each dimension, we identify those features that affect innovation and, by applying the concepts and principles of the innovation studies, we formulate the following propositions:

Hypothesis 1. The involvement of the private sector in PPPs, as risk taking partner, fosters innovation in public infrastructure and services. Higher is the involvement of the private sector in PPPs higher will be the innovative performance.

Hypothesis 2. Bundling all the phases of the project's life cycle (i.e., design, building, financing, operation, and maintenance) increases the innovation investments in PPP.

Hypothesis 3. The private ownership of the asset over the length of the contract always increases the innovation investments in PPP.

Hypothesis 4. The PPP industry structure has an ambiguous effect on innovation: it is neutral or even preventing due to the high level of market concentration that exert opposite or equally negative forces on the innovation development.

Hypothesis 5. The structure of the PPP contracts, where the only specifications are on outputs and on the performance (service) requirements of the infrastructure asset, favors innovation and creativity in design, construction technology, management and financing. The likelihood of some innovative activity related to the PPP project is highest when repayment mechanisms are based on performance level.

Hypothesis 6. Sharing the risks between the two parties, the public and the private, increases the probability of innovation investments in PPP.

Hypothesis 7. The cooperation among partners in PPPs, favoring the knowledge exchange among them, enhances the development of innovations. The stronger the trust among partners, the higher the PPP innovativeness.

Hypothesis 8. The engagement in the SPV of a different range of partners allows them to supplement their internal resources and competence with complementary external resources and knowledge. The integration of different knowledge bases, skills, information, behaviors and habits of thought, increases the chance of developing innovation.

An econometric analysis is then applied to empirically test the hypotheses.

The data employed combine information on PPP projects extracted from the World Bank Private Participation in Infrastructure (PPI) Database with data on patents provided by the EPO and the Indian Patent Office database. The empirical analysis refers to a dataset of 164 PPP projects that covers 11 countries over 24 years, 1992–2016, and includes only PPP projects, completed or in operation, in the energy, transport, and water and sewerage sectors, and excludes the telecom sector.

Originality/value

Although the existing studies highlight the potentiality of PPP for stimulating innovation, they do not prove whether and in which conditions the PPP model is capable of developing innovative solutions (Davies and Salter, 2006; Green et al., 2004; Leiringer, 2006). Only few authors question the aforementioned claim, recognizing that the correlation between PPP and the provision of innovative solutions is not as straightforward as it at first might appear (Barlow and Köberle-Gaiser, 2008). Still, while these studies recognize that PPP cannot be considered per se as the panacea for innovation in public infrastructure development but it needs to be properly structured, thus going beyond a mere anecdotal evidence and wishful thinking, they present two main limitations. First, they are based on the observation of few case studies, thus deriving conclusions that are project-specific and context-specific. Second, they explain innovation in the PPP as a result of a limited set of factors.

The results of our study enhance the academic discussion on the role of PPP in fostering innovation. We show theoretically as well as empirically that specific PPP features have diverse effects on innovation, in particular, we define how PPP features have to be structured in order to foster innovation. In addition to the contribution to literature, these results are particularly useful for policy makers who are called to structure these arrangements and stimulate innovation in the public infrastructures and services.

Findings

We find that a wider involvement of the private sector increases the likelihood that some innovative activity related to the PPP project occurs. As for the industry structure, we find that the market concentration is positively correlated to the innovation. As for the contract structure, repayment mechanisms based on performance favour innovation in PPPs. This finding suggests that performance-based contracts should be used in the context of PPP instead of traditional contracts, since they give the private sector strong incentives to deliver infrastructure and services with high quality, efficiency and innovation.

Finally, we suggest that, to fully exploit the networking effects on innovation, cooperation and trusting among partners involved in PPPs should be enhanced.

Research limitations/implications

The contribution of our research is twofold. First, we contribute to fill the gap in the academic literature on PPP and innovation by proving whether and in which conditions the PPP model is capable of developing innovative solutions. Second, we contribute to the practice by defining how PPP fea-tures have to be structured in order to foster innovation, thus providing meaningful guidelines to those called to structure these arrangements.

References

Barlow, J. and Koberle-Gaiser, M. (2008), "The private finance initiative, project form and design innovation: The UK's hospitals programme", *Research Policy,* Vol. 37, pp. 1392-1402.

Davies, A. and Salter, A. (2006), "The great experiment: the impact of PPP on innovation in the procurement and production of capital goods", in McKelvey, M., Smith, K., Holmen, M. (Eds.), *Flexibility and Stability in the Innovating Economy*, Oxford University Press, Oxford.

Eaton, D., Akbiyikli, R., Dickinson, M. (2006), "An Evaluation of the Stimulants and Impediments to Innovation within PFI/PPP Projects", *Construction Innovation: Information, Process, Management*, Vol. 6, No. 2, pp. 63-67.

Edler, J. and Georghiou, L. (2007), "Public procurement and innovation. Resurrecting the demand side", *Research Policy*, Vol. 36, pp. 949–963.

Green, S., Newcombe, R., Frenie, S., Weller, S. (2004), *Learning Across Business Sectors: Knowledge Sharing between Aerospace and Construction*, University of Reading.

Grimsey, D. and Lewis, M.K. (2002), "Evaluating the risks of public–private partnerships for infrastructure projects", *International Journal of Project Management*, Vol. 20, No. 2, pp. 107–118.

Leiringer, R. (2006), "Technological innovation in PPPs: incentives, opportunities and actions", *Construction Management and Economics*, Vol. 24, pp. 301–308.

9. Project Management Trends in the Automotive Supply Chain

Alberto De Marco, Paolo E. Demagistris, Giulio Mangano

In the automotive Original Equipment Manufacturers (OEMs) industry, the introduction of Project Management (PM) standards and practices is claiming essential to gain both a) improved processes and increased competitiveness of organizations, and b) adaptation to increasing complexity associated with the major shift in mobility paradigms. To help understand managerial perceptions and current trends of PM to enable effective "projectification" of the firms to deal with increasing organizational complexity, this paper illustrates and analyzes a research program based on a survey involving a number of professionals working in automotive OEMs in Italy, an associated case-study analysis jointly developed with a OEM company, and, finally, in depth interviews with selected respondents to the survey's questionnaire.

Design/methodology/approach

A survey questionnaire is developed after consulting the Italian automotive OEMs industrial association. The questionnaire is then circulated among OEMs professionals and about 70 completed responses are analyzed for interpretations and conclusions. The outcome of the survey is compared against a case study documenting the ongoing Agile transformation of the product development lifecycle at a medium sized supplier of automotive assemblies and systems. In depth interviews are finally conducted with selected leaders of projectization within respondents to the survey.

Findings

Main findings reveal that PM practices are still poorly adopted in SMEs, while diffused in large organizations. PM is rather seen as a support function than a core process by most SMEs.

PM is little available in ICT processes and departments, while more used in the R&D functions, product design, and engineering processes. In some way, PM practices correctly extend and improve the core Advanced Product Quality Planning (APQP) core product development lifecycle. PM education and certification programs are seen as a major value by individuals in large companies. PM benefits are mainly perceived as realized in client relationships, market value creation, firm's reputation, as well as process effectiveness to reduce time-to-market and delivering cost and quality project performance.

Within this broader climate of context we identify that the automotive industry is currently positioned in two long tails somehow overlapping and contributing to create different path of complexity creation and evolution: on the one hand, the industry lives in the decline stages of mass motorization, with consumerization of car ownership, on the other, the industry is in its early stages of the new transportation paradigm, characterized by four disrupting forces of market complexity: maturing alternative electric / hybrid powertrains, advances in vehicles connectivity with infrastructure and other vehicles (V2I and V2V respectively), shifts in mobility and ownership preferences, and the emergence of autonomous vehicles.

Within these very different contexts we characterized four clusters of automotive suppliers business models: a) the nimble, suppliers of non-critical components within Just-in-time supply chains; b) the stars, suppliers with capabilities of delivering components within co-design and Just-in-Sequence production systems; c) the brands, suppliers of critical components based on proprietary technologies (own IIP) delivering on co-design and JIT chains: and, finally d) shelf , suppliers delivering non critical catalogue components delivering on FIFO chains. Clusters a) and b) must show high PM agility standards and practices, while the business models c) and d) are mostly competing on intangible and working capital.

By using Shenhar and Dvir's "Diamond Model" of project contingency: Novelty, Technological uncertainty, Complexity and Pace

(NTCP), we characterized emerging patterns of complexity evolutions that corresponds to the 4 business model clusters and to different position in the two long tails of declining and emerging automotive paradigms. We argue that in both cases the lack of support of PM to embrace new behaviors and of enabling IT infrastructure calls for action.

Originality/value

The results reveal that PM diffusion is still underway and that those companies that have gained PM maturity are getting perceived value to market and improved resource usage. The findings underline the crucial importance of PM practices to contribute development of the automotive industry in the coming years.

The questionnaire shows that PM is perceived as a crucial development challenge for increased competiveness of automotive parts manufacturers to face emerging trends of complexity. Large companies that have reached PM maturity can be described at a slope of enlightenment, while most SMEs are still lagging behind schedule in adopting PM practices that would help them to keep track with the main PM-mature leaders of their supply chains.

The case study and its sequent validation shows that most of uncertainties and immaturities are deriving from structural mutations of the industry that are currently perceived as a peculiar contingent situation.

Practical implications

The results of the survey can be used by organizations to better understand their PM maturity stage and take tactical and strategic PM implementation actions accordingly

Research limitations/implications

This work is a contribution to better understand how PM is specifically interpreted when applied to the automotive industry. The empirical study is limited in number and national span of respondent.

Current research is under way to investigate professionals' points of view at an international level.

References

Aggeri, F., & Hatchuel, A. (1998). Managing Creation and Learning of New Expertise in Automobile Development Projects. Projects as Arenas for Renewal and Learning Processes (pp. 157–167). Springer, Boston, MA.

Beaume, R., Maniak, R., and Midler, C. (2009). Crossing innovation and product projects management: A comparative analysis in the automotive industry. International Journal of Project Management, 27(2), 166–174.

Du Preez, N., & Louw, L. (2008). A framework for managing the innovation process. In Kocaoglu, D. F., (Ed.). (2008). 2008 Portland International Conference on Management of Engineering & Technology: Cape Town, South Africa, 27 - 31 July 2008. Piscataway, NJ: IEEE Service Center.

Gosselin, M. (2005). An empirical study of performance measurement in manufacturing firms. International journal of productivity and performance management, 54(5/6), 419-437.

Hab, G. and Wagner, R. (2006), "Projektmanagement in der Automobilindustrie Effizientes Management von Fahrzeugprojekten entlang der Wertschoepfungskette", 2nd ed., Gabler, Wiesbaden.

Khan, M.S., Al-Ashaab, A., Shehab, E., Haque, B., Ewers, P, Sorli, M., and Sopelana, A. (2013). "Towards lean product and process development", International Journal of Integrated Manufacturing, 26(13), 1105-1116.

Lehnerd, A. P., and Meyer, M. H. (2011). The Power of Product Platforms (Reprint edition). Place of publication not identified: Free Press.

Lila Lenoria Carden, T. M. E. (2008). Human Resource Development and Project Management: Key Connections. Human Resource Development Review, 7(3).

Margineanu, L., Prostean, G., and Popa, S. (2015). Conceptual model of management in automotive projects. Procedia-Social and Behavioral Sciences, 197, 1399-1402.

Midler, C. (1995). "Projectification" of the firm: The Renault case.

Scandinavian Journal of Management, 11(4), 363–375.

Müller, A. K., Wald, A., and Görner, A. (2012). Comparing project management practices in new product development: a study in the automotive, aerospace and rail transport industry. International Journal of Project Organisation and Management, 4(3), 203–217.

Niebecker, K., Eager, D. and Moulton. B. (2010). "Collaborative and cross-company project management within the automotive industry using the Balanced Scorecard", International Journal of Managing Project in Business, 3(2), 328-337.

Project Management Institute (Ed.). (2014). Navigating complexity: a practice guide. Newtown Square, Pennsylvania: Project Management Institute, Inc.

Pop, L.D., and Nagy E. (2015). "Improving Product Quality by Implementing ISO/TS 16949." Procedia Technology, 19, 1004-1011.

Remington, K., Zolin, R., & Turner, R. (2009). A model of project complexity: distinguishing dimensions of complexity from severity. In Proceedings of the 9th International Research Network of Project Management Conference. Berlin: IRNOP. Retrieved from http://www.irnop2009.org/IRNOP/about/about.php

Shenhar, A. J., & Dvir, D. (2007). Reinventing Project Management: The Diamond Approach to Successful Growth and Innovation. Harvard Business Review Press.

Too, E. G., & Weaver, P. (2014*). The management of project management: A conceptual framework for project governance. International Journal of Project Management*, 32(8), 1382–1394.

10. Managing Innovation in a complex environment: Hospital 4.0

Pierangelo Afferni

Hospital facilities are going through a phase of deep crisis due to the changing needs of healthcare in our time. The existing structures, based on the model of polyclinic (polyspecialistic structure) developed in the past years, are facing new challenges arising from the aging of the population, the progress of medical science, the increased demand for wellbeing from the population towards the public and private healthcare, and the increase in costs of medical spending to ensure a high standard of safety and quality of the therapeutic result.

The current hospital facilities show the following problems in most cases:

1. Multifunctional approach not integrated and not centered on the patient but on the hospital ward: source of disservices due to the difficulty of coordination between departments and insufficient attention to the needs and general problems of the patient, not only to the medical ones.
2. Scope of quality limited to patient health interventions (for example JCI Standards): other factors that may influence patient satisfaction and in some cases therapeutic efficacy are not taken into account.
3. Quality management based mainly on centralized control (for example JCI Tracer Methodology): lack of responsibility on the part of the healthcare staff, lack of personnel attention towards the patient.
4. Lack of a methodology for the control of the efficiency (reduction of the wastes): the wastes concern the time and the materials and they can also compromise the therapeu-

tic result in addition to increasing the costs.

5. Poor or inadequate IT infrastructure: patient information sometimes lacking, incomplete or unreliable. Increased access time to information.

The purpose of this work is to identify the modalities and characteristics of a change management project to address same of the previously highlighted issues, specifically those at the points from 2 to 4. For this reason the present work identifies in the Lean Six-Sigma methodology together with a new vision of hospital centered on the patient the keys to face the challenges in the hospital field and manage innovation through projects of change towards Hospital 4.0.

Design/methodology/approach

The hospital innovation process, proposed in this study, involves a cultural change of health personnel.

The approach followed to start the innovation process is based on the definition of two important aspects:

- The innovation strategy
- Change management processes

The strategy for a change management project in a complex system such as the hospital system must, in my opinion, envisage an incremental innovation process that starts from a pilot project, in an area that is not too critical but highly visible, so as to constitute a proof of the concept used as an example of success within the structure in order to obtain a broad consensus on the part of health professionals. The pilot project must be strongly sponsored by all the stakeholders directly involved in the project within the hospital.

As for the pilot project, it will be necessary to define a change management methodology tailored for the specific case study. In particular, specific KPIs must be defined in order to measure the change (comparing the indicators before and after the change).

Another important aspect concerns the training of staff. The project requires the use of health personnel already present in the structure, with the help of an external mentor. It will therefore be necessary to precede and support the activities of the project with short training activities of the staff.

Following the completion of the pilot project, it will be possible to evaluate the possibility to start-up other projects in different areas. It will also be useful to evaluate the progress of the transformation of the organization through the use of a maturity model like the CMM (Capability Maturity Model).

Findings

The results of the Lean Six-Sigma method can be both immediately quantifiable, both related to aspects of the quality of the service rendered, such as reducing the probability of making mistakes, improving the organizational climate, increasing patient satisfaction.

Lean Six-Sigma can increase safety and quality, improve staff morale and reduce costs - all at the same time - freeing up human potential that can add value to patient care and improve quality, creating a virtuous circle. The Lean Six-Sigma methodology addresses the crux of the problem: how work is done within an organization. Lean Six-Sigma intuition is that there are infinite ways in which organizations waste time, energy and resources in activities that do not add value to the client, in our case the patient. It is very easy for the accumulation of these wastes to generate worthless assets that stratify by making the percentage of worthless assets outweigh those with added value, often stifling the real potential.

Originality/value

We are at the beginning of a great transformation of health organizations, it would be of great benefit to adopt a continuous improvement methodology. This work concerns the tailoring of the Lean Six-Sigma methodology in the hospital environment and plan for a change management project to deploy the methodology in the organization. The Lean Six-Sigma methodology was born in the industrial field and we have numerous examples of success of its application in several industrial sectors. The proposed approach is quite new, in fact there are only a few examples of practical application in the hospital environment in the world.

Practical implications

Greater experimentation in hospitals could take off the spread of this methodology and as a consequence there would be a great benefit with the reduction of healthcare costs and an improvement in patient satisfaction.

Research limitations/implications

As in all complex organizations, there is great resistance to change in hospitals, and the difficulty is even greater where health risk is considered the most important element. Basically, the difficulty could be overcome with training courses for health personnel and with the involvement of the health management in order to represent innovation as an opportunity for growth towards excellence to increase patient satisfaction.

References

Tucker, A. L. and Edmondson, A. C. (2003), "Why hospitals don't learn from failures: Organizational and psychological dynamics that inhibit system change", *California Management Review*, Vol. 45.

JCI (2017), *Joint Commission International Accreditation Standards for Hospitals*, Joint Commission Resources.

Tokognon, J. et al. (2014), "Service innovation and TQM: A conceptual framework of customer satisfaction," in MSMI 2014 Conference Proceeding, pp. 167–171.

Van den Heuvel, J., Does, R. J. and De Koning, H. (2006), "Lean six sigma in a hospital", *International Journal of Six Sigma and Competitive Advantage*, vol. 2, no. 4, pp. 377–388.

Stamatis, D. H. (2011), "Essentials for the Improvement of Healthcare Using Lean & Six Sigma", CRC Press Productivity Press.

Watson-Hemphill, K. and Nissen, B. K. (2016), "Innovating Lean Six Sigma: A Strategic Guide to Deploying the World's Most Effective Business Improvement Process", McGraw-Hill Education New York.

Breen, G. et al. (2009), "Improving doctor–patient communication: Examining innovative modalities vis-à-vis effective patient-centric care management technology", *Journal of medical systems*, vol. 3

PART IV

ORGANIZATIONAL LEARNING FOR DRIVING COMPLEXITY

11. Investigating project complexity from an organisational learning perspective: a multiple case study

Alberto F. De Toni, Elena Pessot

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. Dealing with the interdependency, uncertainty and change of contemporary projects and their dynamic environments poses new challenges (Cooke-Davies et al., 2007) and requires a more contingent approach in managing projects, beyond the conventional linear systems and the "Tayloristic one best-way approach" as a reference model to apply to any type of project or industry (Blindenbach-Driessen and van den Ende, 2010; Shenhar, 2001).

This connects with the specific challenges encountered by organisations when capturing and embedding new knowledge and learning from the management of single projects at the overall organisation level (Bresnen et al., 2004; Prencipe and Tell, 2001). Project teams need to deal with the interfaces between the temporary and permanent organisation they belong to (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).

This work aims to investigate how organisations are facing the complexity of their projects based on the reflections and perspectives of the learning gained by the project management teams at the organisational level. We build on 1) the dimensions of project complexity identified in the project-oriented literature, i.e. diversity, interdependency, dynamicity, uncertainty, and 2) the key organisational processes of organisational learning in projects environments (Prencipe and Tell, 2001), i.e. knowledge creation through experience accumulation, knowledge acquisition (from other sources or contexts), knowledge codification. In order to answer the following research question:

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

Design/methodology/approach

Aiming for sense-making and increasing the understanding of the features of complexity and organisational learning processes in projects, this study employs a qualitative methodology and an exploratory approach (Yin, 2013). Moreover, it follows the need to take into account the organisational context within which projects are embedded and interact, extending the contingency-based approaches (Shenhar, 2001). Therefore, we conducted a multiple case study where the cases have been a sample of projects managed and delivered by the same organisation, i.e. a large, leading company of the shipbuilding industry. We selected a population of 7 cruise ships' projects showing complex multivariate conditions (Yin, 2013), with a variance on the criteria (Eisenhardt, 1989; Shenhar and Dvir, 1996) of: size of the ship, technological newness, shipyard (production site), delivery date (therefore corresponding to different timings in the development process), customer (highlighting the features with an impact on the design and production phases, i.e. newness of the customer to the firm and to the market, type of relationship, customer segmentation, innovativeness).

The phase of data collection employed multiple sources to enable triangulation (Yin, 2013) and lasted for more than one year. The sources of evidence were interviews, field notes, qualitative questionnaires, documents and archives. A database was prepared for each case, including primary and secondary sources, and data were analysed following a two-step procedure, involving a within-case analysis and a search for cross-case patterns (Eisenhardt, 1989) in terms of dimensions of project complexity and organisational learning processes.

Findings

Results of the study show how project teams understand and face the complexity of their projects and determine further insights on studying organisational learning as an emergent process. Table 4.1 summarises he main mechanisms carrying to specific sub-processes of learning when dealing with different complexity dimensions in the analysed projects.

Tab. 11.1. Complexity dimensions and organisational learning in projects

	ORGANISATIONAL LEARNING PROCESSES		
COMPLEXITY DIMENSIONS	EXPERIENCE ACCUMULATION	KNOWLEDGE ACQUISITION	KNOWLEDGE CODIFICATION
DIVERSITY		• common knowledge base • innovations and advance-ments	
INTERDE-PENDENCY	• trust mecha-nisms • on-site training	• economies of repetition • collection of feedbacks • cross-fertilisation of competences	• systematisa-tion of inter-faces • improvement of standard procedures • organisational redesign
DYNAMICITY	• focused meet-ings • fluidity of in-formative pro-cess		• specific man-agement tools • systematic re-views
UNCERTAIN-TY	• informal pro-cedures • overcoming of "cultural gap" for knowledge sharing		

In general, dealing with the management of complex projects re-sults in a considerable level of organisational learning, taking place in the project teams.

Focusing on the levels of single dimensions of project complexity, we can observe the prevalence of single processes of experience accumulation, knowledge acquisition and knowledge accumulation. For instance, a higher level of both interdependency and dynamicity results in a higher knowledge codification, to be promptly shared in the emergent knowledge communities. 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 or strict regulations) allows for a better learning at organisational level to be translated in common knowledge repositories. A higher diversity mainly results in the need to acquire knowledge from the external sources, especially from the previous projects, the past experiences of the team members and also the competences of the main stakeholders, when properly shared. The dimension of dynamicity results in 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 acquisition and codification, to be properly shared and transferred in the upcoming projects.

Originality/value

This study contributes to the stream of literature on project complexity by enriching it with an organisational learning perspective. It can be situated at the interface between project management and organisational studies, offering insights for a theory building aimed at studying organisational learning in project environments as an emergent process of complexity.

The findings are likely to advance knowledge on the issues of managing projects characterised by a certain level of complexity, by acknowledging the importance of considering the emerging mechanisms of experience accumulation, knowledge acquisition and knowledge codification of project management teams when they face the complexity of their projects.

Practical implications

This research can provide some useful indications for the management of projects with reference to the definition, assessment and management of project complexity. The complexity dimensions proposed in the study may help project managers and other project stakeholders to better understand the complexity of the projects they are working on. Moreover, the perspective of organisational learning 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 project management teams with a basis to eventually adjust their project management practices and/or organisational learning processes accordingly, especially when they develop more projects to realise the company's strategic objectives.

Research limitations/implications

The research has been completed in February 2018. Major limitations are linked to the choice of the research design, i.e. the case study and the qualitative data analyses performed, that limits generalisability. Despite this, 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.

Moreover, the selection of the cases and the boundaries established in the design of the research limited the scope of the study. Therefore, the investigation of multiple projects from different organisations, also on a multi-sectoral basis, would allow to extend and refine the lessons learned here. 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.

References

Blindenbach-Driessen, F. and van den Ende, J. (2010), "Innovation in project-based firms: The context dependency of success factors", *Journal of Product Innovation Management*, Vol. 27, No. 5, pp. 705-724.

Bresnen, M., Goussevskaia, A. and Swan, J. (2004), "Embedding New Management Knowledge in Project-Based Organizations", *Organization Studies*, Vol. 25, No. 9, pp. 1535-1555.

Cooke-Davies, T., Cicmil, S., Crawford, L. and Richardson, K. (2007), "We're Not in Kansas Anymore, Toto: Mapping the Strange Landscape of Complexity Theory, and Its Relationship to Project Management", *Project management Journal*, Vol. 38, No. 2, pp. 50-56.

Eisenhardt, K.M. (1989), "Building Theories from Case Study Research", The Academy of Management *Review*, Vol. 14, No. 4, pp. 532-550.

Maylor, H. and Turner, N. (2017), "Understand, reduce, respond: project complexity management theory and practice", International Journal of Operations & Production Management, Vol. 37, No. 8, pp. 1076-1093.

Prencipe, A. and Tell, F. (2001), "Inter-project learning: processes and outcomes of knowledge codification in project-based firms", Research Policy, Vol. 30, No. 9, pp. 1373-1394.

Shenhar, A.J. (2001), "One size does not fit all projects: exploring classical contingency domains", *Management Science*, Vol. 47, No. 3, pp. 394-414.

Shenhar, A.J. and Dvir, D. (1996), "Toward a typological theory of project management", *Research Policy*, Vol. 25, No. 4, pp. 607-632.

Stjerne, I.S. and Svejenova, S. (2016), "Connecting Temporary and Permanent Organizing: Tensions and Boundary Work in Sequential Film Projects", Organization Studies, Vol. 37, No. 12, pp. 1771-1792.

Yin, R.K. (2013), *Case Study Research: Design and Methods (Fifth Edition)*, SAGE Publications, Thousand Oaks, CA.

12. Facing project complexity by Advanced Work Packaging: an application in Benetti Yachts

Davide Aloini, Elisabetta Benevento, Annamaria Diprima, Francesco Ricci

Project complexity is a critical topic in construction project management (Bakhshi et al., 2016; Lu et al., 2015). Researchers have increasingly recognized the importance of complexity, particularly in large-scale projects (He et al., 2015; Davies and Mackenzie, 2014), as one of the factors affecting expected project outcomes (time, cost, quality, etc.) (Bosch-Rekveldt et al., 2011; Dao et al., 2016).

Project complexity involves dynamism and uncertainty, which are mainly manifested in technological and organizational complexity (Baccarini, 1996; Lu et al., 2015). Accordingly, mega construction projects are usually characterized with high technological complexity, such as building type, overlapping of design and construction works, dependency on project operations, and uncertainty of the production process or customer demand (Bosch-Rekveldt et al., 2011; He et al., 2015). In addition, the nature of complexity in such projects is related not only to their scale, but also to organizational/coordination issues. Indeed, complex projects are conducted by a network of organizations which includes various teams, project staff, multiple organizational structure and, thus, is often hard to manage (Davies and Mackenzie, 2014; He et al., 2015).

Due to poor coordination and integration between the various project participants, Engineer-To-Order (ETO) manufacturers – such as industrial constructor– typically face low levels of work productivity and project predictability (Gosling and Naim, 2009). Such deficiencies in productivity and predictability of outcomes can notoriously be turned around through a proper early planning approach that involves and coordinates the engineering, procurement, construction and project controls areas with a supply chain orientation (Yeo and Ning, 2006).

In the very last few years, Advanced Work Packaging (AWP) methodology (CII RR 272-2, 2013) has been emerging as a successful planning methodology within the industrial construction environment. AWP is based on the concept of breaking the project scope into smaller portions with planned and managed installation. The project is divided into Construction Work Packages (CWPs), which are large sections of the project construction activities, and Engineering Work Packages (EWPs), which are deliverables from engineering activities. The CWP/EWP designations are then merged together, iteratively decomposed and issued to the field for completion (Figure 12.1).

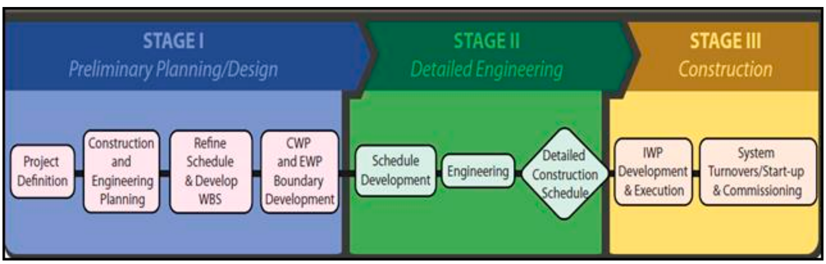


Fig. 12.1. Advanced Work Packaging diagram flow (Source: CII RR 272, 2013)

Besides few explorative experiences within the industrial construction sector, the implementation of Advanced Work Planning technique is still embryonic in other ETO industries. Also, to the best of our knowledge, there is lack of empirical research aimed at testing and validating the AWP methodology directly in the field. Particularly, no empirical contribution has provided quantitative measurement of the performance resulting from a proper implementation.

Due to above-mentioned research gaps, this paper aims at investigating the suitability of AWP methodology to the shipbuilding context. In addition, the research aims to provide preliminary evidence of the potential benefits related to the AWP implementation.

Design/methodology/approach

The AWP implementation was conducted in Benetti Yachts, one of the largest yacht-builder in the world. The case study methodology goes through the following six main steps:

1. **Project order selection**. A mega-yacht (60 mt.) order was selected in order to test the AWP implementation. The choice was determined by a lower design and production complexity of the mega-yacht orders respect to giga-yachts and the availability of historical data for setting up AWP and assess comparisons (more than 20 mega-yachts were built by Benetti). A set of indicators was also identified in order to evaluate improvements due to AWP application.
2. **Modelling and analysis of actual construction process**. Meetings with process participants, extensive document analysis, and accurate direct observation of work activities were conducted to identify the main phases of the shipbuilding cycle and map the construction process. A BPMN model was built which includes the planning and production activities along with various project participants.
3. **CWA plan development**. By the process model and the work breakdown structure (WBS) of past mega-yacht projects, we developed a CWA plan with the collaboration of the project team. Specifically, we broke the entire project into different geographical construction work areas (CWAs). Each CWA has different size (boundaries) depending on the logical association of work and the activity type. Sizing of CWA is aimed at estimating and monitoring the progress of the project.
4. **CWP plan and EWP plan development**. For each CWA, we identified a set of construction work packages (CWPs), with the support of the construction management. Each CWP is fed by one or more engineering work packages (EWPs). An EWP is produced by the engineering team and provides CWP with technical documentation, such as drawings. After that, constraints and dependencies between a CWP and the related EWPs were identified by interviews with engineers. In addition, where relevant, CWP and EWP development also allowed to define Procurement Work Packages (PWPs).

5. **IWP plan development**. Each CWP was finally divided into several installation work packages (IWPs). Each IWP contains all elements necessary to complete the installation of a scope of work in the field. Figure 12.2 shows the relationship between CWA, CWP, EWP and IWP.

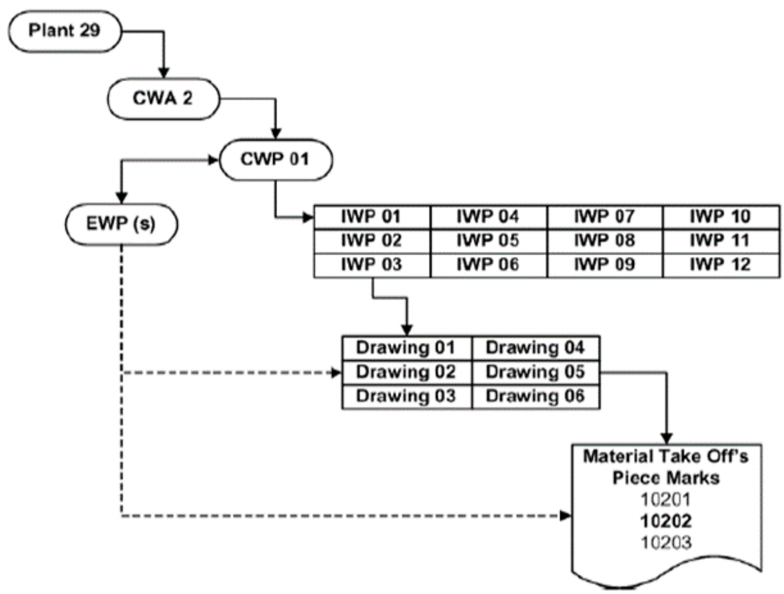


Fig. 12.2. AWP structure

6. **Project implementation and AWP test.** The mega-yacht project will be executed and monitored following the AWP project plan as defined in the previous steps and project data will be collected by an appropriate AWP sw tool. Then, project performance will be evaluated and compared with previous project orders to check the potential benefits of the AWP. Periodical meeting with project team will be also planned to identify possible shortcomings of the AWP methodology and define directions to refine it accordingly.

Findings

A new project plan related to the 60-meter yacht was defined accordingly to AWP methodology. The project plan was also implemented in a Microsoft Project application in order to support project execution and monitoring phases. Specifically, we identified:

- 22 CWAs, 66 CWPs and about 200 drawings for the outfitting phase;
- 27 CWAs, 27 CWPs and about 140 drawings for the hull and superstructure construction phase.

Figure 12.3 shows, as an example, a CWA and the related CWPs, EWPs and PWP defined for the low deck of the vessel.

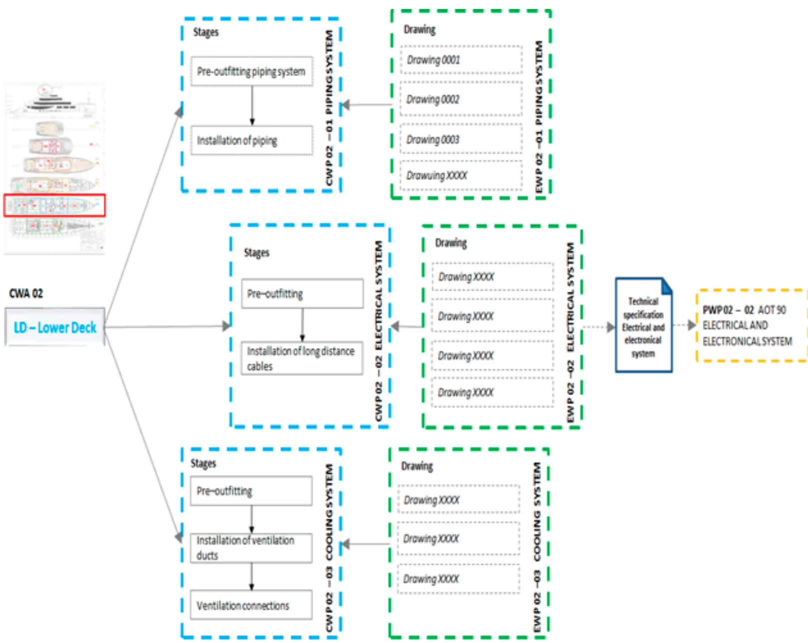


Fig. 12.3. Relationship between AWP, CWP, EWP and PWP for the low deck of the vessel

Expected results from the AWP implementation mostly concern with the increase in labour productivity and alignment with the planned schedule, both of them resulting from fewer reworks and improved alignment among project participants. Indeed, an early identification and mitigation of constraints should allow achieving reduced project over-time and extra-cost, which are also estimated with more reliability and robustness. These expected improvements are also related to a set of ancillary benefits in other areas, such as improved project flexibility, enhanced accountability and measurability.

In Table 11.1 we show selected indicators to quantify and compare improvements by AWP methodology.

Originality/value

To our best knowledge, this is a first attempt to implement the AWP methodology and test its feasibility in the shipbuilding context. In addition, the research also aims at providing early empirical evidence of the expected benefits theoretically related to the AWP implementation.

Research limitations/implications

The empirical test of the AWP methodology is limited to a single case (project order) which is still in progress. Consequently, reported evidence is still partial and results will not be generalizable. Nevertheless, this work could be a valuable starting point for replication in other cases/industries.

Tab. 12.1. Performance indicators

Dimension	Metric	Formula
Time	• Schedule Variance Index	$\frac{Actual\ Schedule}{Planned\ Schedule}$
	• On-time Engineering	*Average delay in drawing releases*
	• Overall Project Completion	*Actual days for project completion*
Cost	• Cost Variance Index	$\frac{Actual\ Cost}{Planned\ Cost}$
	• Rework Savings	*Rework Cost Reduction*
Quality	• Engineering Rework Factor	$\frac{\sum Drawings\ with\ Reworks}{\sum Drawings}$
	• Production Rework Factor	$\frac{\sum Token\ with\ Reworks}{Total\ Token}$
	• Total Field Rework Factors	$\frac{\sum Reworks\ Costs}{Total\ Production\ Cost}$

References

Baccarini, D. (1996), "The concept of project complexity—a review", *International journal of project management*, Vol. 14, No. 4, pp. 201-204.

Bakhshi, J., Ireland, V., & Gorod, A. (2016), "Clarifying the project complexity construct: Past, present and future", *International Journal of Project Management*, Vol. 34, No. 7, pp. 1199-1213.

Bosch-Rekveldt, M., Jongkind, Y., Mooi, H., Bakker, H., & Verbraeck, A. (2011), "Grasping project complexity in large engineering projects: The TOE (Technical, Organizational and Environmental) framework", *International Journal of Project Management*, Vol. 29, No. 6, pp. 728-739.

CII RR 272-2, (2013), *Advanced Work Packaging: Design through Workface Execution*, The Construction Industry Institute, Austin, TX.

Davies, A., & Mackenzie, I. (2014), "Project complexity and systems integration: Constructing the London 2012 Olympics and Paralympics Games", *International Journal of Project Management*, Vol. 32, No. 5, pp. 773-790.

He, Q., Luo, L., Hu, Y., & Chan, A. P. (2015), "Measuring the complexity of mega construction projects in China—A fuzzy analytic network process analysis", *International Journal of Project Management*, Vol. 33, No. 3, pp. 549-563.

Gosling, J., & Naim, M. M. (2009), "Engineer-to-order supply chain management: A literature review and research agenda", *International journal of production economics*, Vol. 122, No. 2, pp. 741-754.

Lu, Y., Luo, L., Wang, H., Le, Y., & Shi, Q. (2015), "Measurement model of project complexity for large-scale projects from task and organization perspective", *International Journal of Project Management*, Vol. 33, No 3, pp. 610-622.

Yeo, K. T., & Ning, J. H. (2006), "Managing uncertainty in major equipment procurement in engineering projects", *European journal of operational research*, Vol. 171, No. 1, pp. 123-134.

13. Explorative and Exploitative Learning in Infrastructure Megaproject: a case from the Hong Kong-Zhuhai-Macao Bridge

Yan Liu, Marcel Hertogh, Huimin Liu, Erik-Jan Houwing

Infrastructure mega-projects are characterized by their temporary and one-off nature, long-term design and construction cycle, and high organizational, technological and environmental complexity. It is difficult to directly apply general project management methods to mega-projects. It is important to take advantage of lessons learned within projects and from other projects in terms of avoiding a tendency to 're-invent the wheel'. As the project is seen as a temporary organization, project-based learning can be considered as temporary organizational learning.

However, it has been acknowledged in the literature that it is challenging to learn in the project context, not to mention in programs and megaprojects (Brady and Davies 2004; Dutton et al. 2014). There are two research questions (1) what are characteristic of the learning process in infrastructure megaprojects, and (2) How is the balance between internal and external knowledge sourcing achieved? The aim of the article is to stimulate discussion about how internal knowledge bases and processes, and external knowledge flows contribute to the infrastructure megaproject management and how they co-exist.

Design/methodology/approach

Describe research design or the approach for studying the industrial case, methods of data collection, data sources, analysis, and validation.

In practice, the Hong Kong-Zhuhai-Macao Bridge (HZMB) project offers immense opportunity for the research on learning process to the management practices of infrastructure mega-projects. HZMB is situated at the Pearl River Estuary of the Lingdingyang Sea, which consists of 29.6 km of dual three-lane carriageway in the form of a bridge structure, a tunnel of about 6.7 km, and two artificial islands. HZMB links the Hong Kong Special Administrative Region (HKSAR), Zhuhai City of Guangdong Province, and the Macao Special Administrative Region in China. Construction formally began on 15 December 2009 and the structure was completed on 14 November 2017. The total cost of the main bridge was $7.56 billion.

A longitudinal study has been carried out between 2011 and 2017. Data is collected from the access to the archival project logs, participant observation and interviews with senior project managers. An initial extraction of the data set resulted in all learning-related events from the case. These learning related events were categorized into two main types of learning modes: exploration and exploitation. Explorative learning is defined as the search for new knowledge and explorative learning is defined as the ongoing use of the knowledge base (Vermeulen and Barkema 2001).

Findings

As an infrastructure mega-project, there are some inherent new characteristics in HZMB. The construction methods have more transitioned from the traditional site-construction methods to pre-industrialized production or rapid manufacturing approaches. The complexity of the project asks to bring in more new project participants like special equipment and material suppliers, immersed tunnel design and construction consultancy and so on. Last but not the least important, there are many first encountered situations in this megaproject due to the complex environmental conditions and two separate legal systems (Mainland China and Hong Kong and Macau) so that there are no similar past lessons learned.

HZMB was delivered successfully and the project we observed exhibited ambidexterity, which means that exploration and exploitation co-exist in infrastructure megaprojects. The authors integrated the two strategies of exploration and exploitation into the mega-project management. Results show that explorative learning is used to explore new engineering technology and knowledge. By contrast, exploitative learning is used to define the system architecture, interface relationship, technical index, and other functions. In particular, the exploration strategy could transform complex problems into systematic problems, which the exploitation strategy could solve thereafter. The efficient integration of two types of learning, ambidexterity, could improve the design and construction performance. The results revealed that the co-evolution between exploration and exploitation has shaped the learning process in infrastructure megaprojects and has further affected the evolution and operation across various stages of project development.

Originality/value

The megaproject is so complex that a single contractor and designer cannot solve problems and look ahead the future alone. Prior research has highlighted the importance of explorative and exploitative learning within and across projects. The research tentatively explores the learning in an infrastructure megaproject, the world's longest sea bridge, and analyses the practical and explicit benefits of taking advantage of new and existing knowledge. For researchers, we contribute to the project learning literature with a megaproject perspective. The value of conceptualizing ambidexterity at the project level is demonstrated in the research.

Practical implications

It is essential that learning occurs. Project managers should be aware of the learning in megaprojects and adapt their learning behaviors in order to brace the project complexity. We propose that infrastructure megaproject managers must proactively absorb external knowledge resources and strengthen their own expertise and develop flexible learning capabilities. Actors, especially international contractors, and engineering consultancy will benefit from understanding the logic of learning.

Research limitations/implications

There are limits as to how far the conclusions based on single case study can be generalized. To generalize conclusions to the learning process in infrastructure megaprojects in general, probably surveys are required among a greater variety of organizations.

References

Brady, T. and Davies, A. (2004), "Building project capabilities: From exploratory to exploitative learning", *Organization Studies*, Vol. 25, No. 9, pp. 1601-1621.

Dutton, C., Turner, N., Lee-Kelley, L. (2014), "Learning in a programme context: An exploratory investigation of drivers and constraints", *International Journal of Project Management*, Vol. 32, No. 5, pp. 747-758.

Vermeulen, F. and Barkema, H. (2001), "Learning through acquisitions", *Academy of Management Journal*, Vol. 44, No. 3, pp. 457-476.

PART V

PORTFOLIO, PROGRAM AND PROJECT COMPLEXITY

14. Beyond PPM: On the way to modernization at Italian National Institute of Statistics

Silvia Losco

The National Institute of Statistics is a public research organization that produces and disseminates high-quality statistical information in complete independence, in accordance with the latest scientific standards, in order to develop detailed knowledge of Italy's environment and to assist the decision-making processes. Today ISTAT is facing pressing and emerging challenges going to meet the growing demand for statistics, the speed of technology, improving quality, efficiency and competitiveness and ensuring flexibility and on time deliveries. With the Modernisation Programme (2016), Istat aims to evolve the statistical production system from traditional "silos" survey models towards a model that uses statistical registers. For what concerns organisational item, the managerial problem is to manage the complexity of this deep process of change that involves the organization, at strategical and operational level, with a strong impact on statistical production and on motivation and use of personnel.

Design/methodology/approach

Under a simplification and rationalization perspective, with the aim of moving towards a more effective and modern, as well as less expensive structure, the new organisational model is based on PPM framework at strategical and operational level. The whole ISTAT activity is managed "like projects" (management by project) and organized into "initiatives", elementary units to identify statistical activities, administrative procedures and technical services. Initiatives are proposed by researchers, analysed and approved by managers and included in specific portfolio. According to the statistical Business Architecture model (BA), the thematic portfolios are connected to statistical registers and to services that support statistical production. The model offers 4 portfolio categories: production, support, capacity, strategy. At operational level, the statistical activities organization following a management by project approach that select initiatives and organize the work in phases, with a specific control of deliverables, time, cost and risks associated to the single phase.

Tab. 14.1. Initiatives, Full Time Equivalent (FTE) and Project Managers at Istat for 2018

	Portfolio	N. Initiatives	FTE	N. project managers
Product	National accounts	60	154,5	49
	Individual and households	113	293,8	97
	Business statistics	61	223	45
	Geographical and territorial units	46	127,3	39
Service	Communication and dissemination	40	152,3	37
	Information technology	49	225,6	41
	Methodologies	32	109,1	29
	Data collection	53	348,9	50
	Administrative Services	70	357,3	58
	Governance	41	120,8	35
	Total	565	2.112,5	480

Findings

The introduction of PPM at strategy and operational level to organize all activities, helps ISTAT on strategic alignment to Modernisation Programme, focusing on continuous improvement and incremental innovation, increasing the attention on outputs and efficient management of resources. This choice aims to ensure a more efficient and collaborative use of staff, with a view to transversal in the commitment of resources. This matrix structure is more dynamic than the functional structure and facilitates communication and exchange of information within the organization; information dissemination is more effective because information run both vertical (across various levels of management and from initiative to initiative) and horizontal (across functional lines). Additionally, the model has oriented positively the organization to the development of synergies, encourage knowledge sharing and skills improvement.

Research limitations/implications

The model, actually implemented, includes suggestions for future research and any limitations in terms of resource negotiation and issues connected to the command model (single, dual or multiple command model), which in some cases caused uncertainties and a high level of pressure on individuals.

References

Alleva, G. (2015). *Adding Value to Statistics in the Data Revolution Age*, ISI2015 Rio De Janeiro, 60th World Statistics Congress

ISTAT(2016). Istat's Modernisation Programme, www.istat.it

ISTAT(2017). Strategic Plan 2018-2020, www.istat.it

Project Management Institute (2017). *A Guide to the Project Management Body of Knowledge (PMBOK® Guide)* Sixth Edition – Newton Square, PA: Project Management Institute.

15. Program Governance across enterprises helps govern complexity and creates values across multiple enterprises in a win-win approach

Vincenzo Arnone

In the current globalized world, a dimension of complexity comes from business interactions between multiple companies that are required to generate business value for the whole value chain. In this dimension on top of the typical complexity factors connected with the human factors, the business processes and the organization model within a single company, we also have the complexity generated by multiple companies that need to cooperate in order to achieve specific business outcomes and benefits. Typically, this complexity triggers situations where companies start playing a win-lose approach and this impacts the benefits generated in the value chain.

We will discuss a business case where a Global company worked with an IT outsourcing company across 7 countries in India Middle East. Program Management was used to orchestrate and govern multiple projects across the region that generated significant business value over a 3-year cycle that helped reduce the overall IT cost in a Win-Win approach generating business value for all both players.

Design/methodology/approach

The companies involved in this research asked to keep their names confidential and therefore we will use 2 fictitious names: A&A is the company that has outsourced its IT service and KQ is one of the key outsourcers.

The approach is based on the action research methodology by analyzing a business case where A&A in India Middle East Africa (IMEA) region launched a multi-year program to reduce the cost of

IT service in the region. A&A had in scope 7 countries (India, South Africa, Saudi Arabia, Egypt, United Arab Emirates, Morocco, and Nigeria) and 23 offices in the region. A&A worked with multiple outsourcing companies to develop the portfolio of project that would deliver the expected savings and we will present the view of one the key outsourcing partners (KQ). This business case happened between 2014 and 2016 and I was co-leading as program manager on behalf of KQ with the customer (A&A).

The study was developed according to the following phases (Coughlan and Coghlan, 2002):

- Data Gathering and feedback: We analysed the documents and the processes developed during the execution of the program with the feedback collected by project component members and project and program stakeholders including members of the governance board.
- Data Analysis: Key issues were discussed with the key program stakeholders and solutions were jointly defined and aligned for implementation.
- Implementation: Key processes were implemented using an agile and value creation oriented approach.
- Evaluation: The results (Joint Program Management) were evaluated from a business benefit standpoint on the basis of the achievement of key financial targets at the end of each program phase and at the end of the program.

Findings

Project Management Institute (PMI) defines programs as "a set of related projects, subsidiary programs and programs activities managed in a coordinated manner to obtain benefits not available from managing them individually." (PMI, 2008)

Program Management is a key enabler for delivering business benefits and for enabling the execution of strategies and company vision in all situations where the business outcome requires the execution of a number of interlocked and interdependent projects.

For example, a project delivers a set of new functions into a company Enterprise Resource Planning (ERP) software (project deliverable). Deliverables do not generate value automatically but they will require employees of the company to learn how to leverage these functions into their day-to-day work (the business outcome) and when this new capability becomes embedded into day by day work this will produce improvements in company results (e.g. reduce cost of service) which is the business benefit.

In 2014 (The first year of the program) A&A set the program vision to reduce the cost of IT services in IMEA (India, South Africa, Saudi Arabia, Egypt, United Arab Emirates, Morocco, and Nigeria) by 10%, for achieving this goal involved in the program key IT outsourcing providers among which KQ.

The program plan was to define for each year a number of saving projects that will be used to achieve savings in various areas of the IT spectrum, and these savings would be proposed by KQ service leaders based in all countries at the beginning of each and then following the prioritization process done by A&A an annual program cycle would be defined, executed and monitored.

In the execution of savings project KQ resources led projects with A&A stakeholder (the A&A IT business owner in each site) in each business unit but the project were struggling to produce results and stay on schedule and this was related to two issues:

1. KQ company was helping A&A but there was no reward from a business standpoint, true the customer satisfaction with IT services from KQ grew but also KQ had internal business objectives connected with business growth (revenues) and cost reduction. For KQ this program was not delivering benefits and the A&A program was driving a Win (for A&A), Loose (KQ) approach.
2. KQ resources had no rewards in driving successfully the saving projects because actually KQ was not winning (no increase in revenues, no cost reduction). The rewarding was there only A&A IT resources at site whose reward system was connected the reduction of cost at site.

Fig. 15.1. Complexity coming from diverging business objectives

Diverging business objectives and reward systems often are an underestimated source of complexity in managing programs and projects, especially when there are multiple companies playing a critical role for the success of the program.

This complexity was shown on the fact that we had two governance structures in place, one which was A&A led that was the official governance board and a second one from KQ that can be defined as a shadow governance structure (as shown in Figure 15.2) set by KQ with the aim of minimizing negative impacts (for KQ) in the execution of the multi-year saving program.

Fig. 15.2. Shadow Governance structure

The overall impact of this situation was that the target for the first year was achieved, but with a lot of efforts and no one was really happy to work on this program.

During a top-to-top discussion on what could be done to drive the program with a different speed and in an easier way, KQ mentioned the fact that the overall program was not producing value for KQ and KQ was not clearly playing a role in the governance board of the program. It was also addressed the needed of creating rewards for both A&A and KQ resources playing a role in the program component projects.

In 2015 (the second year of the program) on the basis of the above, following a deep analysis of the situation with interviews of key stakeholders (KQ Project Managers, A&A stakeholders), the following changes were undertook:

1. In the selection of savings projects for A&A, priority was given to projects that could produce benefits also KQ (in terms of revenues and cost).
2. This enabled KQ to shutdown the shadow governance processes because now discussions at program governance levels were done in an open and cooperative environment and all interests were represented and discussed openly.
3. The new governance board declared to KQ and A&A resources working in the program that in the second year a joint reward process would have been defined so that success would have created good things for all participants.
4. A joint-program leadership was empowered so that the saving program was officially co-led by a KQ and a A&A program director.

Moreover, the governance board started a coaching and mentoring campaign with the objective of ensuring that all project teams (composed by A&A and KQ resources) had clearly understood that a win-win approach was the new philosophy.

A key element of this campaign was a joint meeting (held every two weeks), with all project teams' members participating in a virtual way, where the status progress was made as one team, where positive feedback was provided to the teams that were on track, where pressure was made on teams that were lagging behind the target and where key issues were discussed.

This new program vision, based on a win-win approach, with an effective program co-leadership and a co-rewarding process, made a dramatic shift in the results, in fact in the second year we exceed the overall targets set for the program in the second year and we could also increase the overall targets for the three years from 10% to 15%.

At the end of the second year a joint event with people from the two companies was done and key contributors from both companies were jointly recognized for their contribution by the senior management of KQ and A&A, and each company provided rewards and recognitions to these contributors in an independent (since each company has its own mechanisms) yet synchronized way.

During the third year the program was executed in line with the revised targets.

Originality/value

This business case proves that the sources of program and project complexity are coming from different views of the reality and key sources are not only geographical and culture-related issues but also related to business specific aspects, specifically: diverging business objectives and diverging rewards systems.

Traditionally diverging business objectives are considered within a single company (e.g. different priorities in the same company within different regions and within different countries within the same region) but in today's globalized environment the value chain of a company is depending on the value chain of other companies that play a key role in the overall business results.

This interdependency between companies becomes a key complexity factor that Program and Project practitioners should understand and proactively manage to ensure successful execution of Programs and Projects.

A win-win approach for multiple companies is possible but requires a trusted relationship level with key issues addressed at Program Governance level.

PMI indicates that "strategic alignment, integration management and benefits realization are three key considerations for program governance" (PMI, 2016: p.59) and the integration management shall be done not just within the same company but also across enterprises, which means across the value chain in a globalized environment.

Practical implications

According to PMI (2017: pp. 31-32) the taxonomy of complexity that impacts program management has the following elements: Governance complexity, Stakeholder Complexity, Definition Complexity, Benefits Delivery Complexity, Interdependency Complexity, Resource Complexity, Scope complexity, Change Complexity and Risk Complexity.

The business case described confirms three factors that play a pivotal role (Governance Complexity, Stakeholder Complexity and Resource Complexity) and suggests to practitioners that an inclusive approach of Program Governance that includes strategic partner companies becomes a strategic leverage to manage complexity and deliver business value.

Research limitations/implications

Based on the above-mentioned findings I would suggest adding to the taxonomy of complexity (as defined by PMI) a new definition of complexity, connected with companies that play a key role in the overall value chain.

This might be called *Value-Chain complexity* and it is related with the number of companies that play a strategic role in the creation of value for a specific service or product.

This complexity emerged because of the globalized economy and the globalized ecosystems in which businesses need to survive. This complexity might be considered as a sub-element of the stakeholder-related complexity but giving it a specific reference will ensure that the right level of attention is provided since the very beginning of programs avoiding that risks connected with it emerge when it is too late to take action.

Nevertheless, a limitation of the study must be acknowledged: this case study, thanks to a broad perspective, brought some interesting insights over the topic of complexity in the context of program management, but it is a single case that allows little generalizability of results. Future researches should replicate the framework proposed in this study in order to provide additional results on the topic of complexity within program management.

References

Coughlan, P., Coghlan, D., (2002), "Action research for Operations Management", *International Journal of Operations & Production Management*, Vol. 22 No. 2, pp. 220-240.

Project Management Institute (2008), "A guide to the project management body of knowledge" (PMBOK guide 4th Edition), *Newtown Square, Pa: Project Management Institute*.

Project Management Institute (2016), "Governance of Portfolio, Programs and Projects: A practice guide", *Newtown Square, Pa: Project Management Institute*.

Project Management Institute (2017), "The standard for Program Management" (4th edition), *Newtown Square, Pa: Project Management Institute*.

16. The Development Of Door-To-Door Integrated Mobility In The Metropolitan Cities: The Case Study Of The Roma-Lido Line

Ezio Civitareale, Gianna Di Gaetano, Valeria Salvia,

Alessandro Avenali, Giorgio Matteucci

Mobility issue is one of the main open challenges of Rome and strongly impacts on the life quality of the residents. In last decade, the city area has been characterized by important transformations, such as a progressive increase in economic activities and an expansion of the residential buldings both in the suburban area and in the munici-palities on the edge of Rome. Currently, Rome has about 2.9 million residents and records every day more than 1.3 million people who move just for studying and working.

In last two decades, a demographic explosion has characterized the Roman coast where new boroughs have grown up, such as Madonnetta, Malafede, Casalpalocco, Centro Giano, Vitinia-Acilia, Dragona and Dragoncello. This area is characterized by about 350,000 residents, namely, more or less the number of inhabitants of cities such as Bologna or Bari, and by 27 million of travelers per year. In particular, it is in the municipalities IX (Acilia) and X (Ostia) where the highest percentages of commuting are recorded.

This wide area of the municipalities Acilia and Ostia is mainly served by the Roma-Lido railway line, owned by the Lazio Region and managed by Atac. In last years, this line got the sad record of the worst railway line of Italy, mainly due to the frequent cancellations of the programmed rides and to other criticality of the service (e.g. the seniority of the rolling stock, the age of the railway stations).

The line is 28.359 km long and it is entirely double tracked. It connects the station of Roma Porta San Paolo to the southern limit of the Lido di Ostia district. Part of the route inside the Grande Raccordo Anulare is overlapped to that of the metro line B, although the two lines have independent tracks. It counts 13 stops, even if they should have become 14 by the end of 2016, with the stop Acilia Sud, whose construction still appears blocked.

Given the territorial and demographic size of the served area and the attractiveness of the inner Rome boroughs, the upgrading of the line with suitable and targeted investments could certainly contribute to the creation of an integrated transport system for the city of Rome, more consistent with the needs of the transport demand. In last decade, different projects were proposed to upgrade the line but till now, for many distinct reasons (both economic and technical), no one has been definitively accepted and applied by the public decision makers.

Design/methodology/approach

On 5th March 2018, a call for tender related to the purchase of 20 trains serving the Rome-Lido was published. Moreover, on 6th June 2018, the Regional Council of Lazio approved an act in order to publish on the official gazette of the European Union a pre-information notice, in accordance with the provisions of EC Regulation 1370/2007, for the public procedure concerning the allocation for 9 years of the public transport service on the former railways, including the Rome - Lido, whose service contract expires on 30th May 2019. The Region has also made it known that a project financing proposal is currently under examination, the possible declaration of feasibility of which could lead to a distinct and autonomous awarding procedure.

This work first performs an in-depth analysis of the projects presented over the years on the Roma-Lido line, namely, the project financing of the French coalition led by Ratp and the alternative proposal provided by Atac. Then, a third project hypothesis is formulated, which is mainly characterized by infrastructural investments of limited economic amount and management measures aimed at enhance efficiency, such as, the reduction of on-board personnel and the rationalization of the shifts of rolling stock. Finally, on the basis of the daily demand trend, which is characterized by a large increase in travelers from Acilia up to the final destination, and taking into account the potential increasing of the daily demand in the next future, a model of offer has been proposed to satisfy the traffic flow while optimizing the available resources.

Findings

Crucial interventions on the railway infrastructure are identified, such as in particular (i) the design and building of a side track to Acilia for empowering the trains availability in the Acilia stop, (ii) the construction of a pillar for the emergency platform, and (iii) the installation of the rigid catenary as overhead contact system. Such interventions would allow to convert the current Roma-Lido line into a metro line.

Given the described demand analysis and the proposed interventions on the infrastructure, a table timetable (illustrated in Fig. 16.1) and a possible offer model (see Fig. 16.2) have been suggested.

The proposed offer model, which make services consistent with the users' needs, guarantees:

- a high level of attention for the time slots which are crucial for commuting people and for location with high mobility requirements;
- fixed-time departures so as to obtain a clear offer. In particular, due to fixed-time departures, (a) users can adhere to the proposals that they finds suitable to satisfy their needs, (b) schedules are easy to remember for the users, (c) the offer is always the same throughout every day and allows users to plan flexible travel and return solutions;
- effective management of demand variability, where the frequency of rides raises during the peak hours.

Porta S.Paolo	06:45	06:51	06:55	07:01	07:05	07:11	07:15	07:25	07:31	07:35	07:45	07:51	07:55	08:01	08:05	08:11	08:15	08:25	08:31	08:35
Basilica S.Paolo	06:48	06:54	06:58	07:04	07:08	07:14	07:18	07:28	07:34	07:38	07:48	07:54	07:58	08:04	08:08	08:14	08:18	08:28	08:34	08:38
EUR Magliana	06:51	06:57	07:01	07:07	07:11	07:17	07:21	07:31	07:37	07:41	07:51	07:57	08:01	08:07	08:11	08:17	08:21	08:31	08:37	08:41
Tor di Valle	06:55	07:01	07:05	07:11	07:15	07:21	07:25	07:35	07:41	07:45	07:55	08:01	08:05	08:11	08:15	08:21	08:25	08:35	08:41	08:45
Mezzocammino	06:57	07:03	07:07	07:13	07:17	07:23	07:27	07:37	07:43	07:47	07:57	08:03	08:07	08:13	08:17	08:23	08:27	08:37	08:43	08:47
Vitinia	07:00	07:06	07:10	07:16	07:20	07:26	07:30	07:40	07:46	07:50	08:00	08:06	08:10	08:16	08:20	08:26	08:30	08:40	08:46	08:50
Malafede	07:02	07:08	07:12	07:18	07:22	07:28	07:32	07:42	07:48	07:52	08:02	08:08	08:12	08:18	08:22	08:28	08:32	08:42	08:48	08:52
Casal Bernocchi	07:04	07:10	07:14	07:20	07:24	07:30	07:34	07:44	07:50	07:54	08:04	08:10	08:14	08:20	08:24	08:30	08:34	08:44	08:50	08:54
Acilia	07:07	07:13	07:17	07:23	07:27	07:33	07:37	07:47	07:53	07:57	08:07	08:13	08:17	08:23	08:27	08:33	08:37	08:47	08:53	08:57
Acilia Sud	07:10		07:20		07:30		07:40	07:50		08:00	08:10		08:20		08:30		08:40	08:50		09:00
Ostia Antica	07:14		07:24		07:34		07:44	07:54		08:04	08:14		08:24		08:34		08:44	08:54		09:04
Lido Nord	07:17		07:27		07:37		07:47	07:57		08:07	08:17		08:27		08:37		08:47	08:57		09:07
Lido Centro	07:19		07:29		07:39		07:49	07:59		08:09	08:19		08:29		08:39		08:49	08:59		09:09
Stella Polare	07:21		07:31		07:41		07:51	08:01		08:11	08:21		08:31		08:41		08:51	09:01		09:11
Castel Fusano	07:23		07:33		07:43		07:53	08:03		08:13	08:23		08:33		08:43		08:53	09:03		09:13
Cristoforo Colombo	07:25		07:35		07:45		07:55	08:05		08:15	08:25		08:35		08:45		08:55	09:05		09:15
Cristoforo Colombo		06:47	06:57		07:07		07:17		07:27	07:37		07:47	07:57		08:07		08:17		08:27	08:37
Castel Fusano		06:49	06:59		07:09		07:19		07:29	07:39		07:49	07:59		08:09		08:19		08:29	08:39
Stella Polare		06:51	07:01		07:11		07:21		07:31	07:41		07:51	08:01		08:11		08:21		08:31	08:41
Lido Centro		06:53	07:03		07:13		07:23		07:33	07:43		07:53	08:03		08:13		08:23		08:33	08:43
Lido Nord		06:55	07:05		07:15		07:25		07:35	07:45		07:55	08:05		08:15		08:25		08:35	08:45
Ostia Antica		06:58	07:08		07:18		07:28		07:38	07:48		07:58	08:08		08:18		08:28		08:38	08:48
Acilia Sud		07:02	07:12		07:22		07:32		07:42	07:52		08:02	08:12		08:22		08:32		08:42	08:52
Acilia	07:01	07:05	07:15	07:21	07:25	07:31	07:35	07:41	07:45	07:55	08:01	08:05	08:15	08:21	08:25	08:31	08:35	08:41	08:45	08:55
Casal Bernocchi	07:04	07:08	07:18	07:24	07:28	07:34	07:38	07:44	07:48	07:58	08:04	08:08	08:18	08:24	08:28	08:34	08:38	08:44	08:48	08:58
Malafede	07:06	07:10	07:20	07:26	07:30	07:36	07:40	07:46	07:50	08:00	08:06	08:10	08:20	08:26	08:30	08:36	08:40	08:46	08:50	09:00
Vitinia	07:08	07:12	07:22	07:28	07:32	07:38	07:42	07:48	07:52	08:02	08:08	08:12	08:22	08:28	08:32	08:38	08:42	08:48	08:52	09:02
Mezzocammino	07:11	07:15	07:25	07:31	07:35	07:41	07:45	07:51	07:55	08:05	08:11	08:15	08:25	08:31	08:35	08:41	08:45	08:51	08:55	09:05
Tor di Valle	07:13	07:17	07:27	07:33	07:37	07:43	07:47	07:53	07:57	08:07	08:13	08:17	08:27	08:33	08:37	08:43	08:47	08:53	08:57	09:07
EUR Magliana	07:17	07:21	07:31	07:37	07:41	07:47	07:51	07:57	08:01	08:11	08:17	08:21	08:31	08:37	08:41	08:47	08:51	08:57	09:01	09:11
Basilica S.Paolo	07:20	07:24	07:34	07:40	07:44	07:50	07:54	08:00	08:04	08:14	08:20	08:24	08:34	08:40	08:44	08:50	08:54	09:00	09:04	09:14
Porta S.Paolo	07:23	07:27	07:37	07:43	07:47	07:53	07:57	08:03	08:07	08:17	08:23	08:27	08:37	08:43	08:47	08:53	08:57	09:03	09:07	09:17

Fig. 16.1. Proposed train timetable (based on the parameters underlying Atac's solution).

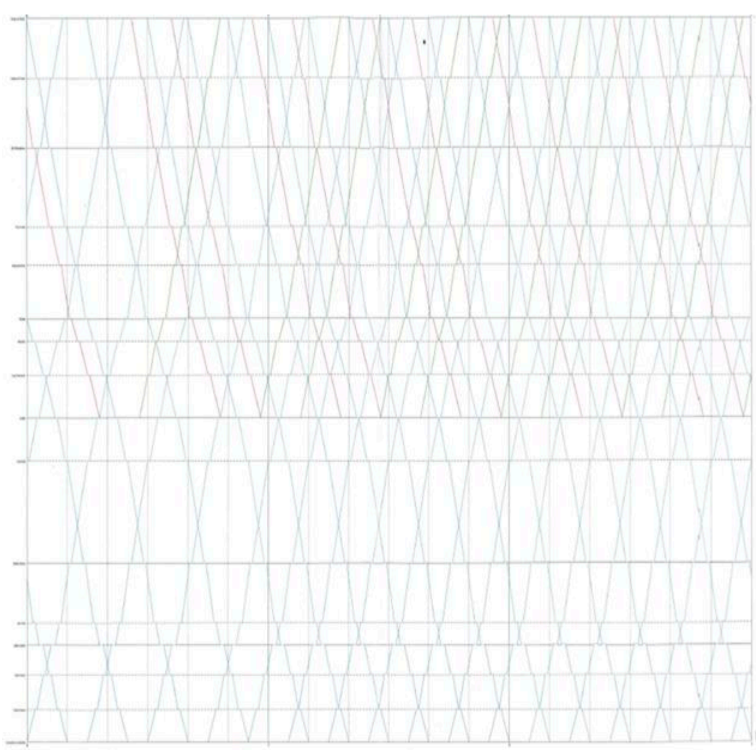


Fig. 16.2. Proposed model of offer

Originality/value

The proposed investments for the modernization of the line and the model of the quoted offer represent concrete interventions through which the public transport of the metropolitan city of Rome would obtain significant benefits relative to the costs. Furthermore, such interventions would finally allow to the line rides to be coordinated with the timetables of other railway carriers in order to achieve a more integrated and effective collective mobility.

Practical implications

The transformation of the Roma-Lido railway line into a metro line, more consistent with the expected traffic flows, would imply an improvement of the quality of the service (more suitable for the mobility needs of the users) and the integration of the service within the integrated transport system of the metropolitan city of Rome. Moreover, it could be a starting point to erase the sad results to be named as the line with the worst-ranking performance in Italy.

Research limitations/implications

Several detailed data on specific parts of the two studied and assessed solutions were scarce and this partially constrained the overall analysis. In the case whereby new data should be provided by the coalition led by Ratp and/or by Atac, a better fine-tuning of the proposed project to upgrade the Roma-Lido line could be performed.

References

Asstra e Aipark, Position Paper: Mobility Report 2017- Idee e soluzioni per la mobilità, giugno 2017.

AsvIS, Rapporto 2017 – L'Italia e gli obiettivi di sviluppo sostenibile, La Buona Stampa s.r.l., Napoli, 2017.

A Boitani, Il trasporto locale e la legge del pendolo, Relazione al convegno - Le priorità per la politica dei trasporti - Venezia, 2013.

J.K. Brueckner, Urban Sprawl: Lessons from Urban Economics, in «Brookings-Wharton Papers on Urban Affairs», Brookings Institution Press, 2001.

A. Cartenì, Regole e documenti nella pianificazione dei sistemi di trasporto, Roma, 2017.

E. Cascetta, Gli spread nel trasporto pubblico locale, Roma, 2015.

Comune di Roma, *Interventi prioritari per il miglioramento della rete del trasporto pubblico e la rete stradale di Roma Capitale. Punti fermi per il Piano Urbano della Mobilità Sostenibile*, Roma, 2017.

Delibera della regione Lazio 26 luglio 2016 n. 437

Delibera della regione Lazio 28 aprile 2017 n. 221

Eurnova srl e Stadio Tdv SpA, *Stadio della Roma Tor di Valle, Generale Mobilità e Studio del Traffico*, Roma 2017.

Isfort, *14° Rapporto sulla mobilità in Italia*, 2017.

Ispra, *Città metropolitane*, in «XIII Rapporto Qualità dell'ambiente urbano», Roma, 2017.

Istat, *Forme livelli e dinamiche dell'urbanizzazione in Italia*, Istituto nazionale di statistica, Roma, 2017.

Ministero dell'economia e delle finanze, *Connettere l'Italia: fabbisogni e progetti di Infrastrutture – Allegato al Documento di Economia e Finanza 2017*, deliberato dal Consiglio dei Ministri l'11/4/2017.

Ministero delle infrastrutture e dei trasporti, *Linee guida per la valutazione degli investimenti in opere pubbliche*, Roma, 2017.

Tomtom, *TomTom Traffic Index*, 2016.

Senato della Repubblica, *audizione dei vertici dell'Atac SpA. in merito alla scadenza e alle procedure di affidamento della concessione del servizio ferroviario sulla tratta Roma-Ostia Lido*, VIII Commissione Lavori pubblici del 25 maggio 2016.

Senato della Repubblica, *Nota Atac prot. 96636 del 24.06.2016 in esito all'audizione dei vertici dell'ATAC SpA. del 25.05.2016*.

PART VI

MODELLING AND ASSESSING COMPLEX PROJECTS

17. Analysing management effectiveness and project performance through a system dynamics approach: the case of software development projects

Stefano Armenia

While existing research has mainly focused on project management's static view, our work investigates the impacts of projects' structure and behavioural dynamics on their performance, with a specific focus on the influence of some peculiar development processes. A dynamic simulation model of a single-phase project was built using the system dynamics methodology. The model integrates several previously developed and tested project structures and adds a separate structure for the negotiation process. Simulations describe the behaviours generated by the interaction of customized development processes in single-phase projects. Project performances are measured in terms of time, quality and cost. Our research aims to show that development processes, as well as shared resource levelling techniques, significantly impact the dynamic behaviour of projects through the feedback, delays and nonlinear relationships which are usually omitted in traditional project management practice, as well as in methods, tools and models, but are very important descriptors of project complexity. Expanding the models used to manage projects to include dynamic features requires a change of focus by researchers and practitioners. The system dynamics methodology provides some of the tools for developing and implementing such an expansion in project models.

Design/methodology/approach

The combination of feedback, time delays, and nonlinear relationships in project structures have been shown to reduce performance and cause them to be very difficult to manage (Thomas and Napolitan, 1994; Reichelt, 1990; Cooper, 1980). The dynamic nature of project behaviour precludes the generation of a single set of decision rules which are robust in the face of all possible project conditions. As a matter of fact, both complexity and dynamic features of projects seems to be poorly understood by managers (Diehl and Sterman, 1995; Sterman, 1994; Paich and Sterman, 1993; Rechtin, 1991). In addition, traditional tools are inadequate for dealing with the dynamic complexity of projects.

A project should be really considered as a man-made goal-oriented open system and, thus, it tends to be unpredictable and unstable. The complexity of projects and of their environment has increased the disruptive effect of subjective human factors. Personal judgement based on past experience is no longer sufficient to cope with this problem. There is a need to understand better the strategic issues of project management and to learn effectively from past failures; this can only be achieved through a more formal systemic analysis.

System Dynamics (SD) may be useful in describing causal and dynamic complexity arising in software projects and organizations, thus eventually allowing for the building of a new set of tools which will support management in decisions as well as allow them to experiment in learning environments and checking out their hypotheses without implementing them first and wait for the, rather often, catastrophic consequences.

Traditional project management models based on the Critical Path Method (CPM) and PERT (Moder et al. 1983; Halpin and Woodhead 1980) provides several tools for trading away good performance in one measure for improved performance in another. For example durations of activities along the critical path can be shortened by adding more resources (Ulrich and Eppinger, 1994; Wheelwright and Clark, 1992; Moder et al., 1983). The effects of altering activity dependencies among activities to shorten the critical path can be investigated (Barrie and Paulson, 1984; Moder et al., 1983). These methods are limited by their use of an indirect project measure (time) and by bundling the characteristics of and relationships among scope, resources, and processes in each activity into a single duration estimate. They also tend to ignore iteration or require that iteration be implicitly incorporated into duration estimates and precedence relationships.

More sophisticated models based on a joint CPM/PERT paradigm address some of these limitations, but cannot fully model development processes. Other research approaches identify some dynamic consequences of different project structures on project performance (Smith and Eppinger 1997; Eppinger et al. 1994; Steward 1981).

Large reductions in cycle time can be realized by applying concurrent development (Wheelwright and Clark, 1992, Womack et al., 1990; Nevins and Whitney, 1989). But the cycle time reduction comes at the cost of increased complexity. Steward (1981) and Eppinger et al. (1990) developed the Design Structure Matrix to investigate the iterative nature of product development. Design Structure Matrices have been used to map (Smith and Eppinger, 1991) and predict (Morelli and Eppinger, 1993) information flows among activities. But the Design Structure Matrix cannot directly model the structure of a development process over time. Other model structures based on project characteristics have been suggested (Rodrigues and Williams, 1996) and described conceptually (Cooper 1980). However, the specific features and characteristics that distinguish different development processes have not been described at a formal model level of detail. Excluding phase-specific development process structures from project models implicitly assumes that those development processes have no impact on project performance. Yet the availability of work as described by the precedence relationships within and between phases is an important constraint on project performance (Rosenau and Moran 1993; Clark and Fujimoto 1991; Wheelwright and Clark 1992; Moder et al. 1983).

A first model was proposed by Roberts (1974) to explore the basic dynamics of R&D projects where the concepts of perceived progress and real progress were first introduced. This model was further improved by Kelly (1970) to consider the management of concurrent projects. The model develop by Cooper (1980) at Pugh-Roberts Associates was the first major practical application of SD to Project Management. Richardson and Pugh (1981) presented a model for the management of R&D projects, which summarises the basic feedback structures of the project management process. Abdel-Hamid and Madnick (1991) applied SD in particular to the software development process for the first time. The models proposed by Lin and Levary (1989) considers an explicit breakdown of the project work into the classic life-cycle stages, providing a more detailed analysis for the schedules, budgets and staff allocation to the project. The above developments represent important contributions for the application of SD to software project management. They introduce valuable concepts and ideas that should be considered in the future. However, most of the reported cases refer to post mortem analysis. Here, the model is used to reproduce the behaviour of completed projects and helps to investigate the causes for deviations.

From the review of the literature we identified several key feedback structure on which we developed our model: the rework structure (Figure 17.1), the labor structure, the schedule structure, the available work structure, the quality structure, the scope structure.

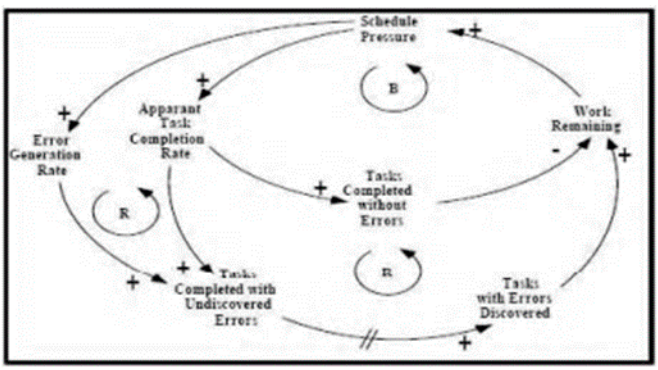


Fig. 17.1. Key feedback structures - Rework (from Ford 1995)

The balancing loop in Figure 17.1 represents the intended impact of a management response to an increase in schedule pressure - reduce the work remaining. The two reinforcing loops represent the impacts of the unintended side effects of the structure - the generation of additional errors which require correction.

SD traditional notation, symbols and lexicon are not recalled in this paper, referring to Sterman (2000).

Findings

For our goal, which is to show and understand the major dynamics which affect software project management, we will limit our analysis to a single phase (coding) of a mono-product software project, that is a portion of its life cycle, spanning over a maximum of 12-24 months (a medium time-dimension for software projects), and we will assume the development team is fully (100% of time) committed on a single project. We will design our model by taking into considerations the main performance indicators of project management, i.e. related to Cost, Time and Quality issues of the released finished product (or a "work in progress" element released to the subsequent phase), and other aspects like Project Complexity, Uncertainty and Risk.

The model is composed by four subsystems: development processes, resources, control and productivity. The development processes subsystem is the focus of this work. Ford (1995) describes the other subsystems in detail.

Our model uses three features to describe the development process in a single phase: circular iteration, multiple development activities, and dynamic concurrence. Circular iteration is described with the stock and flow structure (Figure 17.2).

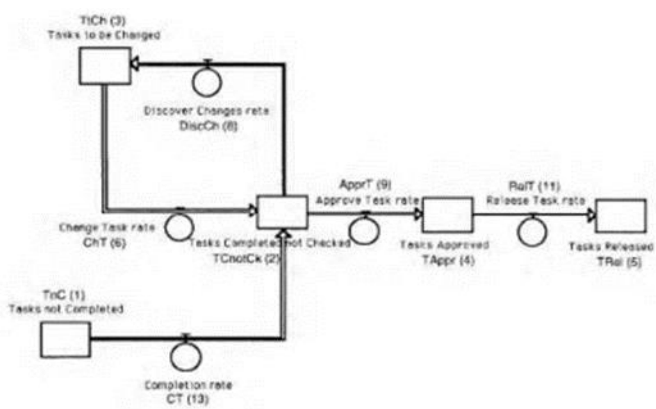


Fig. 17.2. Stock and flow structure of a single phase development process (from Sterman-Ford 200)

We assume that development tasks go through five states: Tasks not Completed (TnC), Tasks Completed by not Checked (TCnotCk), Tasks to be Changed (TtCh), Tasks Approved (TAppr) and Tasks Released (TRel). Tasks initially reside in the Tasks not Completed stock. The first development activity is called "Complete Tasks" (CT).

Completed tasks accumulate in the "Completed not Checked" stock. If no tasks require changes or those changes are not discovered during quality assurance, the tasks leave the Completed not Checked stock and pass through the Approve Tasks (ApprT) flow into the stock of Tasks Approved (TAppr). Approved tasks are subsequently released through the Release Tasks (RelT) flow to the stock of Tasks Released (TRel). This represents delivering tasks to the managers of downstream phases or to customers. Tasks needing changes are discovered through the Quality Assurance (QA) activity.

These tasks move through the Discover Changes (DiscCh) flow from the Completed not Checked stock to a stock of Tasks to be Changed. These tasks are corrected or improved through the Change Tasks (ChT) activity and returned to the Completed not Checked stock. Changes can be generated during both completion and correcting or improving tasks.

We formally model the process structure for our single phase with five equations represented in Figure 17.2 and other 13 equations represented in Figure 17.3.

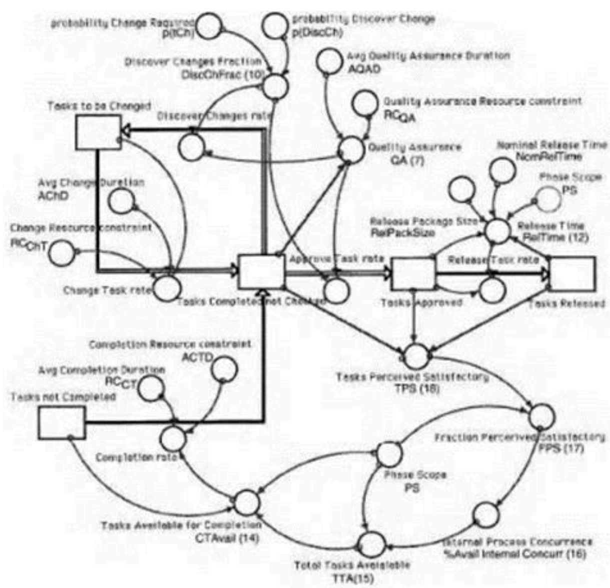


Fig. 17.3. Extended Stock & Flow structure with auxiliaries (from Sterman-Ford 2000)

In the previous section we have seen that development of software in a software project phase go through three main activities: (1)

Task Completion, (2) Task Review, (3) Task Rework. For each of these activities we have seen in the development sector that there is one or more associated flows of tasks. Such a rate represents the activity process itself, that is represents the "speed" at which tasks are processed. In these sense, such activities processing is constrained by the resources allocated to them. Keeping things simple, we saw that the work rate for each activity is equal to the minimum between the speed allowed by the availability of work (divided by the average activity duration) and the speed allowed by the resources allocated to that activity. This means that resources determine the maximum speed at which an activity may be performed.

The project's total Workforce is assumed to be composed by two different workforce elements, namely NewPeople and Experts. In particular, the Average Assimilation Delay in the model has been set to 17 wwk (working week), so almost 85 working days (wday). We divided the workforce into these two categories first because New Hirees almost always pass through an orientation during which they are less than full productive (their weekly overall productivity has been assumed, as it will be seen in the following, half of that of an expert), both if they have been recruited from outside the company and also if they have been transferred from another project. Second, because we wanted to capture also the training overhead involved in adding new members to a software project. The training of newcomers is often carried out directly "on the job" by veterans, which carries away part of the time that an Expert may in effects more productively (in terms of instant project productivity) allocate on development activities.

Any control function has at least three elements:

1. Measurement of what is happening in the activity being controlled
2. Evaluation by comparison with expected values
3. Communication of the gap for behavior control if the need arises for doing so

Progress in a software project (and thus also in a single phase) is measured by the number of resources consumed (effort and/or time), tasks completed or both.

As has been previously stated, a project performance is mainly evaluated through 3 parameters: Time, Quality and Costs. We have developed an index factor for each one of these three elements, which altogether contribute to an overall Project Performance Index:

Project Performance = (Budget Index + Final Quality + Time Index)/3

A case study:

- Original case study: Project Size: 94.100 SLOCs (Single Lines Of Code)
- Estimated effort: 5.000 mandays (Actual: 7.000)
- Estimated Duration: 85 wwk (actual: 110)

We initialized the model with the data from the original case study, taking also into considerations an added factor as the work obsolescence. The latter was considered to provide an added work, over time, of 25% the total initial project size.

- Project Size: 94.100 sloc + 23.000 sloc from the obsolescence factor
- Initial estimated Effort: 3.000fte (full time equivalent)
- Actual Effort Spent: 8942 fte
- Estimated project duration: 85 wwk (with a 30% safety pct, released in only one burst at 90% of the project completion)
- Actual simulated duration: 110 wwk

Overall Performance was attested on a 61%, taking into account costs, time and quality, with the following indexes:

- Time Index: 77,27%
- Budget Index: 35,99%
- Quality Index: 71,00%

The obtained results are in accordance to those which were obtained in the original case-study. A set of input parameters relating to policies for human resource and allocation to activities management, development process management, costs, quality and time management have been identified:

4. Costs section: Safety Cost, Budget effect on Basework
5. Human Resource section: Willingness to change workforce,

Workforce calculation method (accounting for effort/time), Maximum/Minimum desired WF levels, Training

6. Development section: Internal Precedence Relationship (Concurrency Function – technology related), Package release size (release policy)
7. Quality section: Target Quality of the project, Effect of perceived quality on QA allocation (quality gap)
8. Allocation section: initial percentages to activities allocation, effect of Schedule Pressure, Quality Gap and Budget on QA and Basework, Desired Rework delay
9. Time section: Safety time, Forecast of completion date calculations, Release slippage to staff function
10. Client Relationship Management section: Communication of Project progress, Negotiation on change requirements, Client's trust.

Originality/value

Experimentation with most of them have showed interesting results which may help management in understanding the underlying dynamics which are affecting project performance as well as allow management to experiment with different policy parameters in order to correct their mental models according to the way they manage projects.

This research addressed the important issue of the causes of dynamic behavior in software development projects by building, testing and applying a dynamic simulation model of a single-phase project.

Feedback, delays and nonlinear relationships were found useful in describing the drivers of dynamic behaviour. The concept of software development as a set of interactive demand-driven activities was used to build rich descriptions of causal relationships based on previous research. The strong direct and indirect influences of development processes were identified by explicitly separating development processes from resources, scope, and targets.

The research identifies a gap between current project models used for management and the complexity of project structures. A failure to bridge this gap is expected to limit project performance improvement. Expanding the knowledge and understanding of project dynamics is a critical part of meeting this need. The development of new or improved tools, as simulation (dynamic, discrete and/or hybrid) for communication and management practice is also expected to be essential to translating improved knowledge and understanding into improved project performance. This research has contributed insights concerning the dynamics of projects, a tested framework for modelling projects based on demand for development activities, a tool for future research and a tool for improving the understanding of product development practitioners. This work has created opportunities for expanding the study of project dynamics in several potentially valuable directions. This research has pushed project management toward a broader image of projects and its role in project performance. It points to ways of improving performance through improved understanding of project structure and behavior.

Research limitations/implications

Future research will expand and refine the understanding and use of dynamics to manage projects. In particular, the author proposes the extension of the model to a multi-phase software project and to a multi-project environment; the development of standard SD-based project evaluation metrics; the integration at the operational level of our SD model with traditional project modelling approaches

References

Abdel-Hamid, T., Madnick, S.E., (1991), *Software Project Dynamics an Integrated Approach*, Prentice Hall (Englewood Cliffs, NJ)

Barrie, D.S., Paulson, B.C., (1984), *Professional construction management*, McGraw-Hill, (New York)

Clark, K.B., Fujimoto, T., (1991), *Product Development Performance Strategy, Organization and Management in the World Auto Industry*, Harvard Business School Press (Boston, MA)

Cooper, K. G., (1980), Naval ship production: A claim settled and a framework built. *Interfaces,* Vol. 10, No. 6, pp. 20-36.

Diehl, E., & Sterman, J. D. (1995). Effects of feedback complexity on dynamic decision making. *Organizational Behavior and Human Decision Processes*, Vol. 62, No. 2, pp. 198-215.

Eppinger, S. D., Whitney, D. E., Smith, R. P., & Gebala, D. A. (1994). A model-based method for organizing tasks in product development. *Research in engineering design*, Vol. 6, No. 1, pp. 1-13.

Ford, N.D., (1995), The dynamics of project management: an investigation of the impacts of project process and co- ordination on performance, Unpublished PhD thesis, Massachusetts Institute of Technology (Cambridge, MA)

Forrester, Jay W., (1961), *Industrial Dynamics*. Portland, Oregon: Productivity Press

Halpin, D.W., Woodhead, R.W., (1980), *Construct Management*, John Wiley & Sons (New York)

Kelly, J.C., (1987), A comparison of four design methods for real-time system, Proceedings of the 9th international conference on Software Engineering table of contents, Monterey, IEEE Computer Society Press (Los Alamitos, CA, USA)

Kerzner, H. (2006), *Project management: a systems approach to planning, scheduling, and controlling*, Wiley

Moder, J.J., Phillips, C.R., Davis, E.W., (1983), *Project Management with CPM, PERT and Precedence Diagramming*, Van Nostrand Reinhold, (New York)

Morelli, M. D., Eppinger, S. D., & Gulati, R. K. (1995). Predicting technical communication in product development organizations. *IEEE transactions on engineering management*, Vol. 42, No. 3, pp. 215-222.

Nevins, J.L., Whitney, D.E. (1989), *Concurrent Design of Product and Process*, McGraw Hill (New York)

Paich, M., Sterman, J.D., (1993), Boom, Bust, and Failures to Learn in Experimental Markets, *Management Science,* Vol. 39, No. 12, pp. 1439-1458

Rechtin, E., (1991), *Systems Architecting: Creating and Building Complex Systems*, Prentice Hall

Reichelt, K. S., (1990), Halter Marine: A Case Study in the Dangers of Litigation, Technical Report D-4179, System Dynamics Group, MIT Sloan School of Management (Cambridge, MA)

Richardson, G.P., Pugh III A.L., (1981), *Introduction to System Dynamics Modeling with Dynamo*, MIT Press (Cambridge, MA)

Roberts, E.B., (1974), *A simple model of R&D project dynamics*. In E. B. Roberts, (ed.), Managerial Applications of System Dynamics, Productivity Press (Cambridge, MA)

Rodrigues, A.G., Williams, T.M., (1996), System dynamics in software project management: towards the development of a formal integrated network. *European Journal of Information Systems* Vol. 6, No. 1, pp. 51-56.

Rosenau, M.D., Moran., J., (1993), Managing the Development of New Products, Achieving Speed and Quality Simultaneously Through Multifunctional Teamwork, Van Nostrand Reinhold (New York)

Senge P., (1994), *The Fifth Discipline: The Art and Practice of the Learning Organization*, Doubleday & Company, New York.

Smith, R.P., Eppinger, S.D., (1997), Identifying Controlling Features of Engineering Design Iteration, Management Science, JSTOR

Sterman, J., (2000), *Business Dynamics: Systems Thinking for a Complex World*. Irwin/McGraw-Hill

Sterman, J.D., (1994), Learning in and about complex systems, *System Dynamics Review* Vol. 10, No. 2-3, pp. 291-330

Steward, D. V. (1981), The design structure system: A method for managing the design of complex systems. *IEEE transactions on Engineering Management*, Vol. 3, pp. 71-74.

Ulrich, K.T., Eppinger, S.D., (1994), *Methodologies for Product Design and Development*, prepublication draft, McGraw-Hill (New York, NY)

Wheelwright, S.C., Clark, K.B., (1992), *Revolutionizing Product Development, Quantum Leaps in Speed, Efficiency, and Quality*, The Free Press (New York)

Womack J.P., Jones, D.T., Roos, D., (1990), *The Machine that Changed the World*, Rawson Associates, (New York)

18. Formal Requirements Modeling: the tipping point of requirements engineering

Alfredo Garro

System Properties Modeling deals with formally expressing constraints and requirements that the behavior of the system should comply with and that can be verified through real or simulated exper-iments. Although several research activities are focused on the system design phases, there is still a lack of practices and approaches that specifically deal with the analysis, modeling, and verification of re-quirements in an integrated framework that goes from system design to system operation. To this aim, the adoption of model-based meth-ods and tools for supporting the design and the analysis of (cyber-physical) systems, combined with innovative simulation techniques, able to evaluate functional and non-functional requirements, can rep-resent a viable solution.

In this context, the paper presents a solution for formal requirements modeling based on a temporal logic language, called FORM-L (FOrmal Requirements Modeling Language), and a software library, based on the Modelica language, that implements a subset of the constructs provided by FORM-L so as to enable the visual modeling of system properties as well as their verification through simulation. The presented results have been developed in the context of the ITEA 3 – MODRIO (MOdel DRIven physical systems Operation) European Project.

Design/methodology/approach

In the context of the MODRIO project, a new approach to automate the verification of requirements using simulation has been proposed: it suggests defining requirements formally, designing the system architecture, and providing the behavioral models of the system. Requirements, architectural and behavioral models are then bound to verify the system design against the requirements. The formal model of the requirements is used as an observer of the behavioral model to detect automatically violations in the requirements.

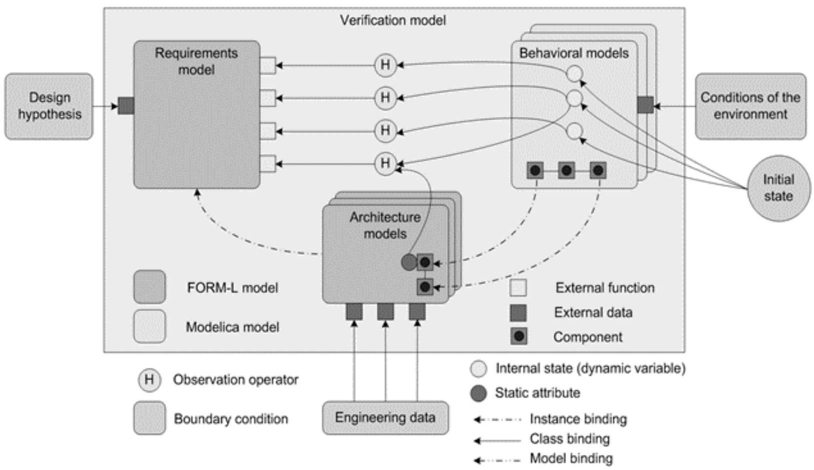


Fig. 18.1. Approach defined within the MODRIO project for simulation-based verification of requirements

Findings

The core of the framework sketched in Figure 18.1 is represented by the Requirements model that derives from an explicit and formal modeling of system properties.

A system property can be defined as an expression that specifies a condition that must hold true at given times and places. System properties can be regarded as *assumptions*, *requirements*, and *guards*. An assumption is a property that is supposed to be satisfied (e.g. that a simulation scenario assumes / ensures that is satisfied). A guard is a condition that must be satisfied for a system to be valid. Requirements are attributes, conditions or capabilities that must be met or possessed by a system or system component to satisfy a contract, standard, specification, or other formally imposed documents. System requirements are defined to ensure the proper operation of complex physical systems (such as power plants, aircraft or vehicles), but also to state functionality that satisfies customer needs. Usually they involve all the steps of the system's lifecycle.

Requirements models may be expressed using standardized graphical annotations based on the UML or SysML standards (e.g. ModelicaML). However, graphical annotations often lack the semantic rigor needed to express requirements without ambiguity. The objective of FORM-L (FOrmal Requirements Modeling Language) is to combine both the semantic rigor needed for automatic processing and the language expressiveness to be understandable by operation engineers. It allows to model systems properties as assumptions, requirements, and guards.

The expression of a property in FORM-L addresses four questions: (i) WHAT is to be satisfied, (ii) WHEN in time the WHAT needs to be achieved, (iii) WHERE in the system the WHAT needs to be achieved, (iv) HOW WELL the WHAT needs to be achieved (as real-life system can and will fail).

Examples of FORM-L expressions, related to properties of a Back-up Power Supply (BPS), are shown in the following to show the main constructs of the language.

R1: The BPS system must not be active when it is under maintenance.

required property R1 =
  during bps.state == maintenance //WHEN
  check not Active; //WHAT

In the proposed framework, a property model is a set of interrelated FORM-L based property declarations and definitions that constitute a meaningful whole. Property models can be organized into a hierarchy according to the system decomposition levels (e.g. System → Subsystems → Equipment → Components).

In order to support and ease the definition of formal requirements models, a software library (called Modelica_Requirements), based on the Modelica language and implementing the constructs provided by FORM-L to enable the visual modeling of system properties as well as their verification through simulation, has been released. In Figure 18.2 an example of requirement expressed by using the visual constructs provided by the Modelica_Requirements library is reported.

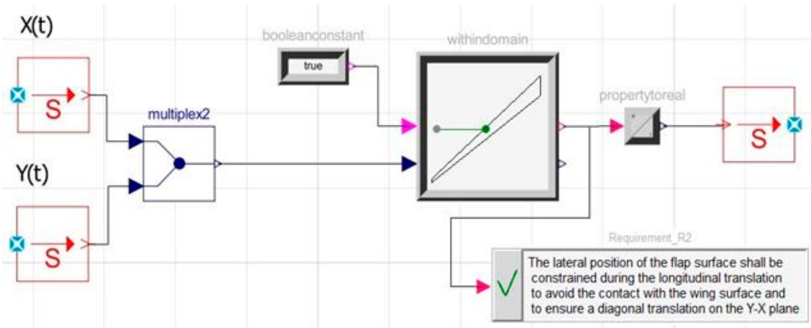


Fig. 18.2. A requirement expressed by using the constructs of the Modelica_ Requirements library.

There are different possibilities to provide data to a Requirements model: (i) a mathematical model describing the system of interest; (ii) data series, stored in files, coming from measurements of real experiments or simulations; (ii) co-simulation of the requirements and the architectural/behavioral models that can be expressed in standard (e.g. UML, SysML, Modelica) or proprietary (e.g. Simulink, Stateflow, Mathematica) modeling languages. Typically, data series are initially used to evaluate the requirements themselves; then a co-simulation with the model of the system is used to automatically verify whether the requirements are satisfied.

Originality/value

The formal requirements specification, respect to the document-based definition, has the following main advantages in terms of requirements management: (i) a reduction of the ambiguity and an increasing in the accuracy, due to the well-defined syntax and semantic of the formal language adopted; (ii) the improvement of the efficiency of the co-work between system manufacturers and suppliers as property models provide a shared and reference representation of systems requirements that can guide testing and early validation of system and subsystem interactions.

Moreover, the possibility to use a stable library for formal requirements modelling along with the Modelica-based visual modeling tools is a clear and remarkable advantage.

Practical implications

The possibility to perform a simulation-based verification of system requirements has the following practical benefits: (i) it lets to understand rapidly if the current implementation is not compliant with the requirements, starting from very early stages in system design; (ii) it enables the comparison of different design alternatives and parameters settings, respect to the specifications, during the design stage; (iii) it allows monitoring the system behavior against the requirements during the operation phase; (iv) it permits to analyze the system operation in case of fault-injections and potentially implement fault-tolerant mechanisms; (v) in case the requirements are subject to modifications, it allows to understand what are the changes to implement to make the system compliant with the new requirements.

The proposed approach to automate the verification of requirements using simulation has been experimented by the industrial partners involved in the MODRIO project in several case studies ranging from the Energy (by EDF) to the Aerospace domain (by DLR and Boeing).

Research limitations/implications

There are two critical points of the proposed approach, on which future researches could make significant advancements: the first is on how to support the automatic transition from the requirements defined in a natural language to their FORM-L representation, while the second is related to the exploitation of co-simulation standards (such as FMI) for model binding. Finally, the association between test scenarios and simulation results it is another crucial aspect, as well as the test scenario generation.

References

Tundis, A., Buffoni, L., Fritzson, P., Garro, A. (2017), "Model-based dependability analysis of physical systems with Modelica", *Journal of Modelling and Simulation in Engineering*, Hindawi Publishing Corporation, UK.

Aiello, F., Garro, A., Lemmens, Y., Dutré, S. (2017), "Simulation-based verification of system requirements: an integrated solution", *Proceedings of the 2017 IEEE 14th International Conference on Networking, Sensing and Control (ICNSC 2017)*, Calabria, Italy, May 16-18, 2017.

Garro, A., Tundis, A., Bouskela, D., Jardin, A., Thuy, N., Otter, M., Buffoni, L., Fritzson, P., Sjölund, M., Schamai, W., Olsson H. (2016), "On formal cyber physical system properties modeling: a new temporal logic language and a Modelica-based solution", *Proceedings of the IEEE International Symposium on Systems Engineering (IEEE ISSE 2016)*, Edinburg, Scotland, UK, October 03-05, 2016, ISBN: 978-150900793-6.

Garro, A. and Tundis, A. (2015), "Modeling of System Properties: research challenges and promising solutions", *Proceedings of the IEEE International Symposium on Systems Engineering (IEEE ISSE 2015)*, Rome, Italy, September 29-30, 2015.

Allegaert, E., Lemmens, Y., Dutre, S., Garro, A., Inzillo, M. (2016), "Architecture-Based Synthesis of 1D-3D Models for Verification and Validation", *Proceedings of the 20th IEEE/ACM International Symposium on Distributed Simulation and Real Time Applications (ACM/IEEE DS-RT)*, London, UK, September 21-23, 2016, ISBN: 978-150903504-5.

Otter, M., Thuy, N., Bouskela, D., Buffoni, L., Elmqvist, H., Fritzson, P., Garro, A., Jardin, A., Olsson, H., Payelleville, M., Schamai, W., Thomas, E., Tundis, A. (2015), "Formal Requirements Modeling for Simulation-Based Verification". *Proceedings of the 11th International Modelica Conference*, Versailles, France, September 21-23, 2015.

19. Improving the integration between BIMs and Agent-Based Simulations: the Swarm Building Modelling - SBM

Gabriele Novembri, Francesco Livio Rossini, Antonio Fioravanti

The construction sector is, currently, one of the most important sectors of the world economy, although it is managed by dated systems compared to innovation that pervades other sectors such as, for example, the automotive. Till now, in fact, it is estimated that about 30% (McKinsley, 2017) of resources globally used in these processes, is dissipated due to management inefficiencies, which can be found both in the design phase and in the executive as well.

This inefficiency is not a new problem, but a constant condition in the construction realm, faced by current developments in digital techniques according to different approaches to the extension of CAD capabilities: from the interactive verification of choices through the use of Augmented, Mediated and Virtual Reality (Park et al, 2013), to the integration between the BIM model and predictive statistical methods, till to the definition of methodologies oriented to the verification of the model through simulation approaches (Scherer et Schapke, 2011).

Despite the development of Collaborative Design methodologies, the analysis of results of different lines of research shows, however, the tendency to discretize the design problem in different 'specialist packages', risking losing of the sense of complexity of the building system, and the repercussions that design choices can have on the entire building organism.

The aim of the research is therefore to provide Actors of the building process appropriate methodologies to manage the complexity of building, and to evaluate the outcomes of these choices in a predictive way. Thus, the prototype under development "*Swarm Building*

Model - SBM" is based on the paradigm of *Agents Swarm*: each agent indeed is able to receive stimuli from the outside, reacting according to their behaviour and objectives, and then involve in any changes all the other agents involved in the system: the result is the adaptation adapting the model to a collectively satisfying behaviour as happens, in nature, with a flock of birds.

Design/methodology/approach

The adopted approach is inspired by the behaviour that some animal species are able to show by creating numerous and complex groups, able to make surprising flock-geometries based on extremely simple behavior of the individual components. Some species are in fact able to create groups of subjects that remain compact and coherent, despite the perturbations applied, thanks to the iterative application of very simple rules.

Despite the apparent simplicity, this approach represents a real revolution in the ways in which the behavior of artificial systems with high levels of interconnection can be simulated, in which the overall behavior is the result of the interaction of the individual elements that compose it.

Similarly to what happens in nature for a swarm, the proposed prototype SBM will be able to react to external stimuli, remaining intact and coherent in the case of addition or subtraction of elements, as is when happen changes in nature or in the behavior of some building components. More generally, changes consist in perturbations represented by new choices or modifications or, in general, variations in the context.

The objects of the building system will follow these changes with the same reaction rate of the flocks in nature: these, in fact, are essentially aimed at maintaining the compactness of the group, like the architect aims to maintain the coherence in the several parts of the building.

So, in the proposed approach intelligent agents will be used to simulate the behavior of building objects for which, in this case, a general meaning is used. A building object can consist of a physical object, an idea or a concept (*design intent*) whose behaviour is relevant in describing the complex system.

The SBM, in this sense, is not only a tool to govern efficiently the building project, but an approach to support stakeholders along the whole building process: the modularity and scalability of the approach used, allow in fact to hypothesize a support system whose composition is not fixed, but varies according to the different phases of the building process, and to the subjects progressively involved.

Thus, to apply this approach, it is not necessary to proceed with the formalization of the whole system, but only the exact definition of the behavior of the individual components, that gradually harmonize the other elements and, as a result, give the correct project.

Findings

The approach adopted is also particularly efficient since the multi-agent are intrinsically based on *execution parallelism*, which makes them particularly suitable for exploiting the potential offered by the modern multi-core processors. The granularity and modularity of which it is equipped also allows the creation of distributed systems, allowing agents to interact simultaneously each other and with the context, regardless of their physical location. The application of the approach brings to the virtual construction of a real "ecosystem" able to give to every stakeholder a wide view on project evolution, a problem-solving approach and, finally, a more effective sharing of choices made by the different actors involved, thanks to a clearer sharing of the *design intent* that substantially in the base of the information itself.

Originality/value

This approach is in line with the research lines of the application of artificial intelligence techniques to the building process. These studies, so far, have always focused on solving specialist problems such as economic forecasts, or the management of complex construction sites, without considering the problem of complexity from a broader perspective.

This research, therefore, aims to provide technicians with a strategic support, able to synthesize the problems of the various sectors and to find solutions that meet the needs of the various players, through compromises and the clear identification of objectives.

Research limitations/implications

From the very beginning of the contemporary 'computational-era', the actors of the building process have found in the computer a valid ally, able to effectively manage important amounts of data and equip, in an ever more *democratic* way, the operators of the sector with instruments that are sufficiently complex, with respect to the insidious complexity of the design problem (Kuntz and Rittel, 1970).

These tools have therefore gradually evolved, depending on the computing power developed by the machines available on the market, allowing at first the possibility to manage geometries and data in separate environments and, from the last decades, modeling information in interconnected holistic environments, such as happens in the BIM approach.

The introduction of BIM systems has unequivocally represented a first important step towards new ways of designing, supporting and managing the executive and dialogue phases and the interaction between the different operators. Despite the obvious limitations (Miettinen et Paavola, 2014), the advantages obtained thanks to these systems now appear to be effective and measurable, even considering the slow and non-homogeneous adoption of this new type of tools.

Although there are several valid prototypes of interaction between designer / artificial intelligence (Cambeiro et al, 2014), the tendency is to focus on the development of these models in specialized field, without going into the *holistic vision* of the building process. Actually, it is to be implemented according to methodologies that prefer the collaborative approach in place of a mere sequential integration of specialisms. Beyond these research lines, the integration of BIM and Agents-based Simulation were developed, maintaining the global vision of the project, towards a synergic collaboration between man and machine (Fioravanti et al., 2017). Finally, among the limits found, the techniques of representation and transfer of *design intent* are ineffective, necessary both as a methodology of '*customization*' of the project, both as an iterative verification of changes and adaptations, occurring every time on the BIM model.

References

AA.VV. (2017) *Reinventing Construction: a route to higher productivity*, McKinsey Global Institute

Carrara, G, Fioravanti, A, Loffreda, G, Trento, A (2014), Conoscere, collaborare, Progettare; *teoria tecniche e applicazioni per la collaborazione in architettura*. Gangemi Editore, Roma, ISBN 9788849229554.

Cambeiro, F P. Barbeito, F P, Castano, I G, Bolìbar, M F, Rodriguez, J R (2014) Integration of Agents in the Construction of a Single-Family House Through use of BIM Technology, *Procedia Engineering*, Vol. 69, p. 584-593.

Fioravanti, A, Novembri, G, Rossini, F L (2017) Improving Proactive Collaborative Design Through the Integration of BIM and Agent-Based Simulations, in Shock! Sharing of Computable Knowledge, proceedings of the *35th eCAADe International Conference in Rome*, 20-22 Sept. 2017. p. 103-108.

Kunz, W, Rittel, H (1970) Issues as elements of information systems, Working paper, Berkeley: Institute of Urban and Regional Development, University of California, Berkeley. <https://www.cc.gatech.edu/~ellendo/rittel/rittel-issues.pdf> last access 12/05/2017.

Miettinen, R, Paavola, S (2014) Beyond the BIM utopia: Approaches to the development and implementation of Building Information Modeling, *Automation in Construction* Vol. 43, p. 84-91.

Park, C-S, Lee, D-Y, Kwon, O-S, Wang, X (2013) A framework for proactive construction defect management using BIM, augmented reality and ontology-based data collection template, *Automation in Construction*, Vol. 33, p. 61-71.

Scherer, R J, Schapke, S-E (2011) A distributed molti-model-based Management Information System for simulation and decision-making on construction projects, *Advanced Engineering informatics*, Vol. 25, p. 582-599.

PART VII

MANAGING RISK AND RESILIENCE OF COMPLEX PROJECTS

20. How to address the uncertainty complexity: a new method for the contingency reserve calculation

Fabio Nonino, Alessandro Pompei

Uncertainty characterizes every project, but although it is a familiar problem, even the most prepared and skilled project manager have difficulty managing it. Moreover, some kind of uncertainty might compromise the success of a project strongly linked to stakeholders' satisfaction (Sutterfield et al., 2006; Yang et al., 2010; Cavarec, 2012).

"Project managers can't predict the future, but accurately gauging the degree of uncertainty inherent in their projects can help them quickly adapt to it." (De Meyer et al., 2002: p.1). In fact, in order to reach the success, project managers (PMs) have to manage different types of risks during project life cycle. As risks are based on uncertainty (i.e. stochastic events), require a complex process of evaluation. This leads PMs to figure out all the potential risks that could take the project out of boundaries planned.

A project risk is an uncertain event or condition that, if it occurs, has a positive or negative effect on one or more project objectives such as scope, schedule, cost, or quality (PMI, 2017). While "risk management is the practice of identifying, evaluating and controlling those factors to avoid or mitigate potential negative effects" as stated by Kliem & Ludin (1997). Project risks are usually addressed in a proactive way. In the case of negative ones, they may be avoided, mitigated or shared using strategies that may require certain actions to be taken and costs incurred. The proactive management of this uncertainty leads to benefits beyond improved control and neutralization of threats. It can facilitate better project performance by influencing and guiding a project's objectives, parties, design, and plans" (Chapman & Ward, 2003).

Research has shown that one of the main factors that contribute to the projects' success is the improvements in the cost estimation techniques including contingency calculation (Uzzafer, 2013).

Methods for contingency reserve estimate could be divided in three macroblocks: deterministic, probabilistic and modern mathematical (Bakhshi and Touran, 2014).

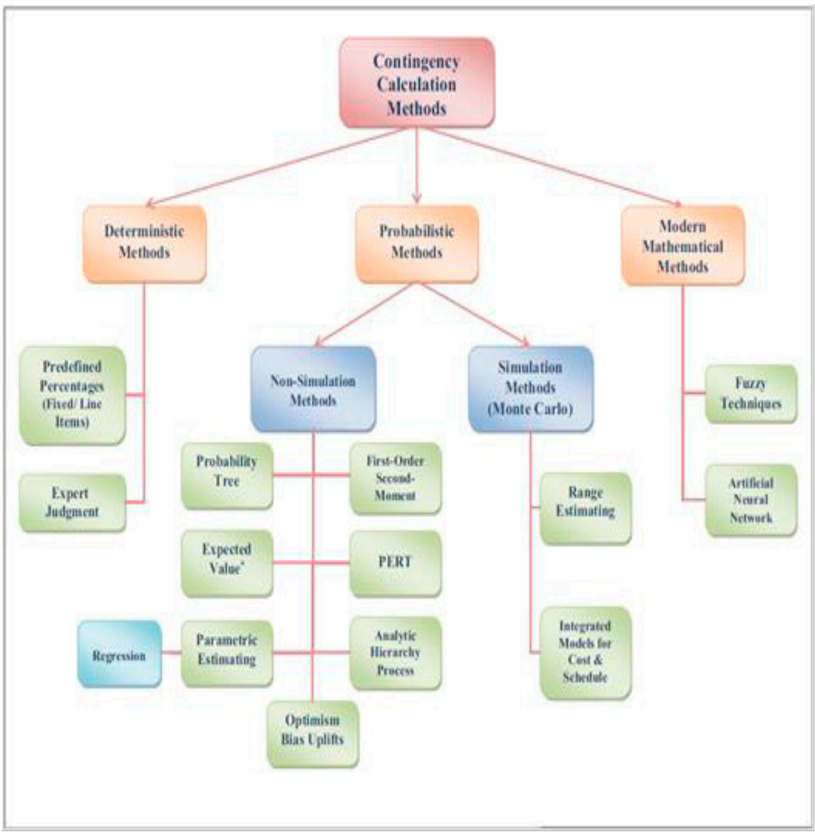


Fig. 20.1. Contingency Calculation Methods (Bakhshi and Touran, 2014)

In our study, we examine in depth the role of Contingency Reserve and methods for its calculation in the context of project costs estimation. Following the definition of PMI (2017), the Contingency Reserve is the budget within the cost baseline allocated for identified risks, which were accepted and for which the project manager has allocated a certain amount, in order to cover expenses for reactive solutions when project is in progress.

Our final objective is to provide a new method for the estimation of Contingency Reserve that will allow project managers to be more efficient in allocating the budget amount dedicated to project uncertainties, avoiding the variations showed above. This method will be easy to use because based on the classic moving average statistical method.

Design/methodology/approach

We created a simulation model to evaluate different methodologies for contingency allocation and to propose a new solution for contingency reserve (CR) estimate. The simulation model will show the different contingency allocation for a sequence of multiple projects characterized by different risks. These risks could have low or high probability of occurrence, which defines the overall risk level of the projects.

The CR allocation will be calculated using three different type of method:

- Predefined Percentage;
- Expected Value with updating;
- Expected Value with Exponential Moving Average method (new proposed method).

According to the applied method, the organization will have extra costs or extra income during the considered time horizon (which consist of projects in sequence) based on the occurrence of risks and the contingency allocation decided before each project. The idea is to evaluate the financial impact of these different methods by making use of the Net Present Value (NPV).

As the simulation model fits well with evaluations involving stochastic events, our intention is to demonstrate when each of the three methods works better (low-risk projects or high-risk projects, as well as project with changing risk probability over time).

To do this, we will analyze different scenarios; each scenario comprises a sequence of n projects, which contain m risks. Different scenarios will have the same risks but different initial probability of occurrence of those risks.

Thanks to this, we want to analyze two types of situations:

- *Increasing likelihood*: we will perform the financial analysis of results of single scenarios by increasing the probability of risks' occurrence before each scenario. The questions we want to address are: Which type of method works better with a sequence of low-risk projects? And with a sequence of high-risk projects? At what level of probability are the trade-offs, if any?

- *Variation over time*: we will perform the financial analysis of results of single scenarios by changing the probability of risks' occurrence during each scenario. The question we want to address is: Which type of method works better with a sequence of projects whose risks change over time?

Findings

The answers to the questions will improve the management of uncertainty from different point of views. In fact, while the former (increasing likelihood) will allow ranking allocation methods relative to the type of projects usually managed by an organization, the latter refers to aspects that affect the single project causing variations and biases for the allocation on the following projects in a certain time horizon. For example, unexpected change in the external environment could have strong impact on some project risks, increasing (or decreasing) their probabilities of occurrence for a certain period.

As real-life projects are often affected by external and internal factors, the objective of the study is to find the optimal solution, knowing not only the type of projects, but also the current context in which the organization acts (low or high variability). Anticipating possible changes and avoiding biases in the contingency calculation process could considerably contribute for project success.

Originality/value

Altough there are few studies about estimation and management of risk reserves (Karlsen and Lereim, 2005), various methods have been proposed and developed with the aim of estimating the project contingency as accurately as possible (see Figure 20.1).

The originality of this study is double and it lies in:

1. Proposing a new method, which is the result of combining

Expected Value method and a simple statistical method like Exponential Moving Avarage.

2. Evaluating the new method comparing it with the two most implemented method based on projects' risk degree and variability.

Practical implications

Traditionally, contingencies are calculated as an across-the-board percentage addition on the base estimate, typically derived from intuition, past experience and historical data. This estimating method has serious flaws (Baccarini, 2005). Most of the methods, techniques and their application are recent (Karlsen and Lereim, 2005); therefore, there is still the tendency of using simple and traditional methods despite all their limitations.

In practical sense, the new method proposed is advanced, but simple to use, and it does not require many technological resources nor advanced mathematical skills to work effectively. Moreover, the study will guide managers to choose the best method according to the intrinsic project riskiness and internal/external environment.

Research limitations/implications

This study is limited to the mentioned three methods, but future studies could address more methods. Furthermore, the simulation reflects the situation in which the organization manages one project at a time, so the possibility of managing projects in parallel, with all the complications involved, is not included yet.

The main limitation of this work is that we did not use real-life data for validate the model based mainly on simple assumptions that could reflect reality somehow. It would be good to test the outcomes of the proposed model by matching them with real outcomes in real projects. By this way, it would possible to verify the practical value as well as the theoretical value of the model.

Finally, our model is not only as scientific tool for the evaluation of different allocation methods, but it could be used as a practical and easy-to-use tool for managerial decision about contingency allocation.

References

Baccarini, D. (2005), "Estimating project cost contingency-Beyond the 10% syndrome", in *Australian Institute of Project Management National Conference*, Australian Institute of Project Management.

Bakhshi, P. and Touran, A. (2014), "An overview of budget contingency calculation methods in construction industry", *Procedia Engineering*, Vol. 85, pp. 52-60.

Cavarec, Y. (2012), "Revisiting the definition of project success", paper presented at PMI® Global Congress 2012—North America, Vancouver, British Columbia, Canada. Newtown Square, PA: Project Management Institute.

Chapman, C. and Ward, S. (2003*), Project risk management: processes, techniques, and insights*, Wiley.

De Meyer, A., Loch, C. H., Pich, M. T. (2002), "Managing project uncertainty: from variation to chaos*", MIT Sloan Management Review*, Vol. 43, No. 2, pp. 60-67.

Karlsen, J. T. and Lereim, J. (2005), "Management of project contingency and allowance", *Cost Engineering*, Vol. 47, No. 9, pp. 24.

Kliem, R. L. and Ludin, I. S. (1997), *Reducing project risk*, Gower Publishing, Ltd.

Project Management Institute PMI (2017), "A Guide to the Project Management Book of Knowledge: PMBOK Guide (6th ed.)", Pennsylvania, USA.

Sutterfield, J. S., Friday-Stroud, S. S., Shivers-Blackwell, S. L. (2006), "A case study of project and stakeholder management failures: lessons learned", *Project Management Quarterly*, Vol. 37, No. 5, pp. 26-34.

Uzzafer, M. (2013), "A contingency estimation model for software projects", *International Journal of Project Management*, Vol. 31, No. 7, pp. 981-993.

Yang, J., Shen, G. Q., Ho, M., Drew, D. S., Xue, X. (2011), "Stakeholder management in construction: An empirical study to address research gaps in previous studies", *International Journal of Project Management*, Vol. 29, No. 7, pp. 900-910.

21. Favouring resilience in increasingly complex environments. Development of an adaptive approach for Large Engineering Projects Management

Franca Cantoni, Edoardo Favari

No contemporary organization is sheltered against complexity (Weick and Sutcliffe, 2001; Cunha and Cunha, 2006). In addition, all the organizations' perception is that the level of complexity is increas-ing. (PMI, 2013). As Giustiniano and Cantoni (2017) state: "Contempo-rary organizations are increasingly asked to deal with high levels of envi-ronmental uncertainty, complexity and equivocality, struggling not only with strong competitive pressures but also with increasing uncertainty relat-ed to socio-political and economic trends. When organizations and their members are confronted with crises, economic distress and 'ugly' surprises, resilience is crucial to their survival. In this sense, promoting resilience has become a major strategic concern for organizations." To face crisis and in-stability in a complex, polymorphic and competitive context, enter-prises need a new perspective being able to combine the "company-centric" logic, in which efficiencies are the highest priority, with the "customer-centric" one, wherein the structure and behaviour of the whole enterprise cannot neglect consideration of full knowledge of the various customer segments (internal and external) with which it interacts. Given these premises, to face this environmental instability and complexity, working for projects and in teams is nowadays habit (Martone et al., 2018). Indeed, workers are constantly asked to man-age a higher number of simultaneous and even more complex and complicated projects to satisfy and retain demanding clients with higher expectations in terms of service quality (Ayres, 2010) and thus ensuring success.

The need for "adaptive" methods for managing projects, in contrast to the traditional "predictive (waterfall)" ones, has arisen since the 90's in the software industry and its milestone is the "Agile Manifesto" published in 2001 (PMI, 2001). In these years several methods to manage agile projects have been developed (Schwaber 1995; DeCarlo, 2004; Augustine, 2005) and this trend helped the predictive methods to evolve (PMI, 2017) (including agile methodologies into waterfall project life cycle).

Starting from this picture, it is clear that there is a strong demand for methodologies enabling organizations to face complexity through adaptive methodologies (Miller, Lessard, 2000).

Currently available adaptive project management techniques have demonstrated, along more than two decades of application, to be critically more effective than the predictive ones in the very specific field of software development; in the last ten years these adaptive techniques have been extended to several others fields, such as R&D or organizational change projects. Today it is generally accepted that a project managed by predictive techniques could also include agile methodologies in some minor part (PMI, 2017), but the most of large engineering projects still have no options than applying a predictive life cycle. At the same time, Large Engineering Projects (LEPs) are facing increasing complexity and uncertainty, so that the application of predictive techniques is even tougher, and the need for adaptive methodologies in this field of project management is stronger than ever. Resilience – here intented as the process followed to anticipate, respond, adapt to, and/or rapidly recover from a disruptive event (Mallak, 1997, 1998; Vogus & Sutcliffe, 2007) - is increasingly becoming an essential feature for organizations involved in large engineering projects. The Authors of this work strongly believe that new adaptive project management techniques are currently essential to practitioners to favour resilience in their upcoming projects.

In this sense, the research is addressed at understanding how adaptive project management techniques, beyond agile, can support and favour organizational resilience in increasingly complex environments such as Large Engineering Projects (LEPs)

Our hyphotesis are here illustrated:

H1: Agile and adaptive project management techniques (currently available) can help resilience in software projects and in several other fields (R&D, organization change, design, etc.) but can't be helpful for LEPs Management facing complexity and uncertainty

H2: Complexity features faced by Large Engineering Projects requires different approaches than the one in the boundary of agile projects (due basically to the dimension of LEPs in terms of economic value, effort and duration, variety of stakeholders involved and their geographical distribution, the nature of their deliverables, the nature of standard international contracts for these projects (eg. FIDIC books….)

H3: It is possible to improve organizational resilience by operating on macro and micro features, so that making the organization adaptive to emerging uncertainty.

Design/methodology/approach

The Authors started sharing their experience in management, resilience and in project management both at academic and practical level, comparing literature and their own previous works concerning complexity and uncertainty environment. In particular, comparison have been made between the organizational theory for resilient organization (Giustiniano & Cantoni, 2017) and the self-organizing teams in project management according to social network analysis theory applied to complex project environment (Favari, 2012; Favari, 2013). The Authors take into account the epistemological problem on investigating complexity, which requires the observer not to be external to the phenomenon, but to be part of it, and the multilevel approach that must be able to connect together contradictory experiences to logic systems. (Morin, 2008).

Findings

This study points out that to make an organization resilient and adaptive to continuous and unexpected environmental change, effort must be made to develop adaptive techniques, in addition to agile techniques, to manage Large Engineering Projects.

Originality/value

This work investigates a field of project management that still has no strong and comprehensive methodology: adaptive (resilient) project management approach to industry and construction projects with increased complexity environment. The result includes overpassing the system theory models in describing complexity, opening to new approaches. In fact, "*although system theory covers the main features of an organization, it is still too generic and not sufficiently exhaustive and accurate to explain and interpret resilient organizations. Managerial theories, individually considered, are not able to explain resilience. In fact, none of them is able to deal with the phenomenon of resilience and all its behavioural and structural features. Instead, theories from other fields can better cope with the phenomenon itself, and with its implications for behaviours and structures*." (Giustiniano & Cantoni, 2017).

Practical implications

The paper already include recommendation that can be immediately applied to project management teams and their organizations in order to improve their response to complexity issues and to make them resilient to uncertainty and emerging problems.

Research limitations/implications

This paper represents the preliminary work of a huge research program. In the following stages the Authors are cooperating with industrial organizations on their project management team to find quantitative indicators to refine and validate their current findings.

References

Ayres J.B. (2010*). Supply chain project management. A structured collaborative and measurable approach* (2nd ed). Boca Raton, FL: CRC Press.

Augustine, S. (2005), *Managing Agile Projects*, Prentice Hall PTR

Cunha, M. P. & Cunha, J.V. (2006). *Towards a complexity theory of strategy. Management Decision*, 44(7), 839-850.

DeCarlo, D. (2004*), Extreme Project Management*, Jossey-Bass

Favari, E. (2013), *Large Transportation Projects Management, a non-linear approach*, Politecnico di Milano

Favari, E. (2012), *Reducing complexity in urban transportation projects, Elsevier-Procedia*, Social and Behavioral Sciences

Giustiniano, L., Cantoni, F., (2017), *"Between Sponge and Titanium: Designing micro and macro features for the resilient organization"*, Learning and Innovation in Hybrid Organizations, Palgrave

Mallak, L.A., (1997). *How to build a resilient organization.* In Proceedings of the Industrial Engineering Solutions 1997 Conference, pp. 170–177, Miami, May.

Mallak, L.A. (1998). *Putting organizational resilience to work*. Industrial Management 40(6): 8–13.

Martone, A., et al., (2018), *Smart working, job crafting, virtual team, empowerment : (progettazione delle posizioni lavorative, nuove soluzioni organizzative, esempi di applicazione),* Wolters Kluwer Italia

Miller, R., Lessard, D.R. (2000), *The Strategic Management of Large Engineering Projects, Massachussetts Institute of Technology*

Morin, E. (2008), On complexity, Hampton Press

Schwaber, K. (1995), *SCRUM Development Process*, OOPSLA '95 Workshop Proceedings, Springer-Verlag London

Vogus, T.J., & Sutcliffe, K.M. (2007). *Organizational resilience: towards a theory and research agenda*. In Systems, Man and Cybernetics, 2007. ISIC. IEEE International Conference, pp. 3418– 3422, October, IEEE

Project Management Institute. (2001), *Agile Manifesto for software development*, http://agilemanifesto.org/

Project Management Institute. (2013), *PMI's Pulse of the Profession In-Depth Report: Navigating Complexity*.

Project Management Institute. (2017), *A Guide to the Project Management Body of Knowledge – 6th edition*. Newtown Square, Pa: Project Management Institute.

Weick, K.E. & Sutcliffe, K. (2001). *Managing the Unexpected: Assuring high performance in an age of complexity*, Jossey Bass, San Francisco, CA.

22. Project risk management in complex socio-technical systems: A resilience perspective

Riccardo Patriarca, Giulio Di Gravio, Francesco Costantino, Massimo Tronci

Complexity is an inherent property of socio-technical activities and represents a continuously growing concept in modern project environments (Marle and Vidal, 2016). Complexity is often used to describe those phenomena that cannot be totally understood and kept under control, oppositely to complicatedness (Ulrich and Probst (1988); Dekker et al. (2012)). A joint combination of the two traditional scientific approaches for complexity management (i.e. descriptive and perceived complexity) has been early acknowledged as necessary to cope with nowadays project management issues (Schlindwein and Ison 2005). Since all approaches for describing complex projects are models of reality, they necessarily deal with the limited perception of the analyst, i.e. his/her improper understanding of reality. Therefore, the approaches to deal with project risks are inherently biased, leav-ing room for the emergence of unforeseeable effects (Baccarini, 1996).

In the last decade, similar observations have been largely explored in the context of risk and safety management for socio-technical systems, leading to the theory of "Resilience Engineering" (RE) (Flin, 2006; Hollnagel, 2011). Acknowledging the limitations of traditional risk approaches, an effective project management should combine traditional risk management with resilience management, where resilience is intended as the ability to recover from endogenous or exogenous shocks or disturbances (Patriarca et al., 2018).

Based on the assumptions of RE, this research aims to explore the potential benefits of adopting the Functional Resonance Analysis Method (FRAM) (Hollnagel, 2012) for modelling socio-technical properties of projects. The research aims to explain how a RE-based approach may favour an effective resilience management, and consequently support the project manager in coping with socio-technical risks.

Design/methodology/approach

The paper refers to the FRAM, which has been largely used to model complex socio-technical systems, mainly for risk management and accident analyses in the context of safety management, see (e.g.) (Furniss et al., 2016; Melanson and Nadeau, 2016; Patriarca et al., 2017). The FRAM relies on four basic principles, which are here discussed with reference to current project risk management characteristics (Hollnagel, 2012):

- Principle of Equivalence. Project failures and successes have the same origin: they emerge from everyday performance variability, i.e. on how operators in the project behave in their day-to-day work. Functional variability allows both things go right and things go wrong, depending on complex interactions among tight-coupled agents and processes.
- Principle of approximate adjustments. People as individuals, as groups, or as organizations, adjust their performance to match the operating scenario. Nevertheless, in any project activity, these adjustments become unavoidable, due to intractability and under-specification of work conditions. The adjustments remain approximate due to the limitedness of resources, or even due to the local rationality of the worker in the project.
- Principle of emergence. Not every event during project lifetime can be linked to one (or multiple) linear static causes. Many events are emergent, rather than resultant from a specific combination of static conditions. Dynamic combinations of time and space conditions during the project might make emerge an event, not leaving detectable traces by *ex post* analysis. This principle represents also a paradigm shift to the label of human error, since failures usually cannot be explained only by referring to individual malfunctions, but are rather a symptom of complexity-driven project criticality.

- Principle of Functional resonance. The functional resonance represents the detectable signal emerging from the unintended interaction of everyday variability for multiple signals. This variability is not random, it rather depends on recognizable behaviours of the agents involved in the project, which act dynamically, based on their local rationality and on the available resources.

Starting from the FRAM, projects should be described according to a functional perspective, where a function refers to the activities that are required to produce a certain outcome. The FRAM thus implies a thorough analysis of project activities, as a preliminary step to manage complexity, and detect potential resonant couplings. For this purpose, the FRAM suggests modelling functions (i.e. what an individual, group, technological agent does) following six fundamental aspects, i.e. Input (I), Output (O), Time (T), Control (C), Precondition (P), Resource (R), put at the corner of a hexagon, the peculiar FRAM basic element (Hollnagel, 2012). Then the FRAM prescribes modelling each interaction between upstream and downstream functions in order to study how each interaction might be variable, thus leading to functional resonance (Figure 22.1 presents a simple FRAM model).

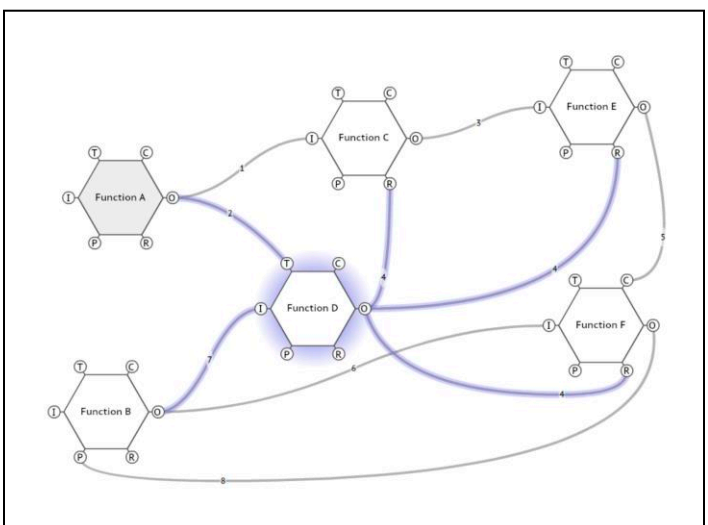


Fig. 22.1. A simple FRAM model made up of 6 functions.

Findings

Effective project risk management cannot be based exclusively on hindsight, nor rely on error tabulation and the calculation of failure probabilities. Projects are complex, and such data are not necessarily available or reliable. A functional representation and understanding of complexity has the potential to support more realistic perspectives to manage project risks, and project resilience.

Following RE, a FRAM approach does not consider performance variability, of any kind, as a threat to be mandatorily avoided. Rather than focusing on developing constraining means (in particular for human performance variability) such as barriers, interlocks, rules, procedures and the use of automation, a FRAM model prioritizes areas for in-depth analysis of variability, leading either to reduce, or to amplify it, at least if acknowledged as non-critical and even necessary for project success. In RE, performance variability is considered both normal and necessary: it is the source of both positive and negative outcomes. Project success cannot be obtained exclusively by constraining performance variability, since that would also affect the ability to achieve desired outcomes. The solution is instead to dampen the variability that may lead to negative outcomes and at the same time to reinforce the variability that may lead to positive outcomes.

Originality/value

Following the logic of RE, this research proposes the possibility to explore a methodological alternative to traditional risk management techniques for project risk management through the support of a recently introduced method, i.e. the FRAM. This latter is intended as a method to partly mitigate several main impacts of project complexity, i.e. ambiguity, uncertainty and propagation (Marle and Vidal, 2016). About ambiguity, the FRAM acknowledges the impossibility to deal with exhaustiveness in identifying criticalities, and proposes a new perspective to identify a series of emerging events, which not necessarily would remain visible in case of failure-oriented analysis. About uncertainty, the FRAM complexity-based modelling techniques have been proved to be supportable by quantitative or semi-quantitative analysis, (e.g.) Monte Carlo simulation (Patriarca et al, 2017a). About propagation, the inherent non-linear foundation of FRAM, and its constituent functional resonance principles provides a foundation to cope with the limitation of linear causality reasoning.

Practical implications

It is worthy to notice that the applicability of FRAM has been recently enhanced by two software, both openly downloadable, i.e. the FRAM Model Visualizer (Hill and Hollnagel, 2016), usable to depict interactions graphically, and the myFRAM (Patriarca et al., 2017b), a VBA-based tool to formally support large-scale analyses and generate systematic data about the FRAM model.

Research limitations/implications

Managing project risks is a never ending challenge; and it has been proved to be a crucial area for project managers, as it represents a key factor for project success. Following the benefits of previous FRAM applications in a variety of scenarios for risk and safety management, this research promotes future applicability of the FRAM, and in general of RE-driven reasoning, for an eclectic effective project risk management.

References

Dekker, S., Bergström, J., Amer-Wåhlin, I., Cilliers, P. (2012). "Complicated, complex, and compliant: best practice in obstetrics". Cogn. Technol. Work 15, 189–195. doi:10.1007/s10111-011-0211-6

Flin, R. (2006). "Erosion of managerial resilience: From Vasa to NASA," in Hollnagel, E., Woods, D.D., Leveson, N. (Eds.) *Resilience engineering: Concepts and precepts*. Ashgate. Publishing, Ltd., pp. 223–234.

Furniss, D., Curzon, P., & Blandford, A. (2016). "Using FRAM beyond safety: a case study to explore how sociotechnical systems can flourish or stall". *Theoretical Issues in Ergonomics Science*, *17*(5-6), 507-532. doi:10.1080/1463922X.2016.1155238

Hill, R., Hollnagel, E. (2016), FRAM Model visualizer. Online resource, available at: http://functionalresonance.com/FMV/index.html [last access 31-05-2018].

Hollnagel, E., (2011), "Prologue: The scope of resilience engineering," in: Hollnagel, E., Pariès, J., Woods, D.D., Wreathall, J. (Eds.), Resilience Engineering in Practice: A Guidebook. Ashgate Publishing, Ltd., MINES ParisTech, France, pp. xxix–xxxix.

Hollnagel, E., 2012. FRAM: The Functional Resonance Analysis Method - Modelling Complex Socio-technical Systems. Ashgate.

Marle, F., Vidal, L.-A., (2016). *Manging Complex, High Risk Projects. A guide to Basic and Advanced Project Management*. Springer-Verlag, London. ISBN: 978-1-4471-6785-3

Melanson, A., & Nadeau, S. (2016). "Managing OHS in complex and unpredictable manufacturing systems: can FRAM bring agility?" *Advances in Ergonomics of Manufacturing: Managing the Enterprise of the Future* (pp. 341-348). Springer, Cham.Adv. Intell. Syst. Comput. doi:10.1007/978-3-319-41697-7_30

Patriarca, R., Di Gravio, G., Costantino, F., (2017a). "A Monte Carlo evolution of the Functional Resonance Analysis Method (FRAM) to assess performance variability in complex systems". *Safety Science*. 91, 49–60. doi:10.1016/j.ssci.2016.07.016

Patriarca, R., Di Gravio, G., Costantino, F., (2017b). myFRAM: An open tool support for the functional resonance analysis method, 2017 2nd International Conference on System Reliability and Safety (ICSRS), Milan, 2017, pp. 439-443. doi: 10.1109/ICSRS.2017.8272861

Patriarca, R., Bergström, J., Di Gravio, G., Costantino, F. (2018), "Resilience engineering: Current status of the research and future challenges", *Safety Science*, 102, 79–100. doi:10.1016/j.ssci.2017.10.005

PART VIII

COMPLEXITY OF PROJECT VALUE ASSESSMENT

23. A Real Options Model to Project Management

Simone Gitto

Traditional methodologies of investment analysis rely on direct costs and ignore management actions, strategic options and flexibility. When undertaking an investment, there is value that derives from having the opportunity to abandon, delay, stage or modify when new information is available (Boute et al., 2003). In the practice, uncertainty and competitive interactions are likely to occur and the realization of cash flows will probably differ from what was estimated. As new information becomes available and uncertainty about market conditions and future cash flows is gradually resolved, managers may depart from and revise the starting operating strategy (Dixit and Pindyck, 1994).

Project scheduling holds most of the flexible decision structured that are allowed in a real options framework. It may be uncertain whether a project will be implemented, the processing time or the resource capacity for the project may be undetermined yet, or other sources of uncertainty may arise. When scheduling an uncertain project, project management may have the possibility to wait for future information in order to reschedule the project as this new information becomes available. Using traditional techniques such as net present value (NPV) or decision tree analysis may lead to false results (Boute et al., 2003).

Many projects have several common characteristics: the investment may be irreversible and the payoffs are volatile, but they may include also the flexibility to postpone the project or to obtain further information using a pilot project. Some projects may be very complex, but it is possible to split and implement them in stages. This is analogous to a financial option: in the real options framework, an opportunity to invest is similar to a call option. The analogy between a financial option and a real option is that an investment opportunity is like an option where there is the right but not the obligation to implement the project (Huchzermeier and Loch, 2001). Real option analysis allows the inclusion of characteristics such as uncertainty, strategic actions and flexibility in the project's value by assigning them a value. By contrary, traditional methodologies fail to evaluate flexibility and undervalue investments (Campisi et al., 2018).

Design/methodology/approach

The economic evaluation of investment has been widely discussed in literature: NPV or internal rate of returns are the most common traditional methodologies applied to analyse the viability of projects. These methodologies are applied to analyse the decision on a new investment in a stable environment. They implicitly assume that a project will be undertaken now and operated continuously until the end of its expected useful life, even though the future is uncertain. Therefore, they ignore management actions and other flexibilities that are included in a project. On the contrary, real option analysis include uncertainty, flexibility and risk management, evaluating such aspects in the volatility associated to the project. This does not mean that NPV calculations should be scrapped, but rather it is a crucial and necessary input to an expanded, option-based analysis. The right value of the project with the option consists of two components: the static NPV of direct cash flows, and the option value of operating and strategic flexibility (Huchzermeier and Loch, 2001).

In finance, a call option is the right of buying an (underlying) asset at a fixed price (label exercise price) during an established period. Analogously, a real option represents the right of taking an action on a physical asset (for instance to launch a project), at an established cost during a period.

For illustrative purpose, it is considered a project that is divided into five sequential stages. The use of five stages is arbitrary, and does not influence the general result. At the end of each stage, there is the possibility of deciding whether to proceed according to the plans made at the beginning of the decision process by implementing the part of the project or ultimately to cancel the part under investigation. The decision process continues until the final of the five phases of the project are reached. The possibility to split a large project into independent stages and of using pilot projects to evaluate the main characteristics of the project is not new in project management. In fact, project manager has the possibility to wait for further information as the basis for reorganising the project. This flexibility is intrinsic in many project and it allows to increase the project's value (Boute et al., 2003; Huchzermeier and Loch, 2001). In this case, the option to defer occurs five times, analogously to five call options: in other words, the option to defer a part of the project is considered five times.

Following Cox et al.(1979), binomial tree is used: it is assumed that the maturity date of an option is divided into discrete periods (*Δt)* and the values are discounted at a risk-free rate *r*. The price of the underlying asset (*S*), changes according to random coefficients related to current positive or negative market conditions. So, the final value will affected by increasing (*u*) or decreasing (*d*) factors that reproduce positive or negative conditions.

The numerical value of the coefficients depends on both by the volatility of the investment (*σ*) and by the lengths of periods. Then, in the first choice (starting period), the value of the asset being *S*, there are two feasible outcomes: *Su* and *Sd*. In the second period, the feasible set is represented by Su^2, *Sud* and Sd^2. This is repeated for the other periods and so on. Notice that the coefficients are obtained as:

$$u = e^{\sigma\sqrt{\Delta t}} \qquad (1)$$

$$d = e^{-\sigma\sqrt{\Delta t}} \qquad (2)$$

whereas, the probability of the values to increase (risk-neutral probabilities) are given by:

$$p = \frac{e^{r\Delta t} - d}{u - d} \qquad (3)$$

Decreasing values are obtained by $q=1-p$. Once the parameters are computed, the binomial tree can be constructed in order to calculate the possible pay-off and roll back the values by means of risk free probabilities. Then, the option value is computed at the final nodes of the tree as *max(S0 – K, 0),* where *S0* is the value of the asset in a node and *K* is the value of the investment (the amount that should be spent on the investment). Starting from the final values of the tree (the right side nodes), the other nodes are computed applying the neutral possibility on each pair of adjacent nodes. One node of the option value tree V_t is computed as

$$V_t = [pV_{t+1,u} + qV_{t+1,d}]e^{-r\Delta t} \qquad (4)$$

The starting node of the value tree (the left node) will be the option value of the project. Then, it is considered five different options with different maturity dates and equal to the periods 1,2,..,5. Therefore, the tree of the underlying asset is the same for the five options while there are five different option value trees (one for each module of the project). The sum of the five values will result as the real option value.

Originality/value

A certain degree of flexibility is introduced in the five stages by means of five subsequent choices corresponding to the exercise of five options. In each step, the decision to invest is taken if the present value of expected future cash flow of the project exceeds the value of the investment. The stock price results as the value of the underlying asset at the starting time and is obtained as present value of future revenues. With respect to the conventional case, it is need to consider that: i) the present value computation does not include the investment costs because they are considered as exercise price in the real option model; ii) the estimated revenues are divided by the number of the phases of the project (five) because each phase is independent. Accordingly, also the exercise price in each period is given by the cost of investment divided by the number of phases. The risk free rate of returns namely is usually set equal to the return rate of Italian bounds with a maturity of 10 years (Campisi et al., 2018).

Research limitations/implications

The proposed real options model can be used to evaluate the economic feasibility of several projects, considering uncertainty and multi-stage investment. The economic value obtained from real option analysis will be higher of that obtained from NPV analysis because the latter does not consider some flexibilities of the project and the strategic dimension of the investment. The ability to reduce or delay the project until more information is available provides to the decision-makers the opportunity to modify the project and the strategy to follow. In this regard, real option theory is a useful tool in evaluation of projects with high uncertainty.

References

Boute,R., Demeulemeester,E. and Herroelen, W. (2004),"A real options approach to project management", *International Journal of Production Research*, Vol.42, No.9, pp.1715-1725.

Campisi, D., Gitto, S. and Morea, D. (2018), "Economic feasibility of energy efficiency improvements in street lighting systems in Rome", *Journal of Cleaner Production*, Vol.175, pp.190-198.

Cox, J.C., Ross, S.A., Rubinstein, M. (1979), "Option pricing: A simplified approach", *Journal Financial Economics*, Vol.7, pp.229-263.

Dixit, A. and Pindyck, R. (1994), *Investment under uncertainty*, Princeton U. Press.

Huchzermeier, A. and Loch, C.H. (2001), "Project management under risk: Using the real options approach to evaluate flexibility in R&D", *Management Science*, Vol. 47, No.1, pp.85-101.

24. How to estimate Project Value? A literature review and a multidimensional index proposal

Fabio Nonino, Giulia Palombi

This study aims to contribute to research in the field of benefit and portfolio management by investigating literature on project value concept.

In the last years, the idea that project value (PV) is a sum of tangible and intangible elements (PMBok Guide, 2017) became commonly accepted. The need for a holistic approach supplementing value creation with value capture have been also recently highlighted (Laursen & Svejvig, 2016); nevertheless, there is still not a clear and exhaustive definition in literature that clarifies which are the elements whose sum would constitute PV.

In order to identify and report the state-of-the-art regarding PV, the present study starts from a systematic review of literature that aims answering the following research questions (RQs):

- How is PV defined?
- How is PV measured?

Moreover, starting from answers,

- How can PV be estimated using a multidimensional perspective?

Design/methodology/approach

We conducted a systematic literature review (Collins and Fauser, 2005; Macpherson and Holt, 2007; Pittaway et al., 2004).

The advantages deriving from this research approach are linked to the scientific and transparent research process divided in three phases: (1) planning the review, (2) conducting the review, (3) reporting and dissemination. During the first phase of the analysis, we identified the main objects of the research; this allowed us to choose, in the phase of planning, the research keywords. Considering the research focus, we decide to look for only those articles that explicitly use the term "Project Value".

During the second phase, we looked for "(Project) AND (Value)" in Title and Abstract and we decided to adopt Ebsco and Scopus online databases for the research. The following step consisted in refining research boundaries with selection/exclusion criteria, and we focused only on papers published on peer-reviewed journals, in English. Further, papers were examined in a double selection process, first based on title and abstract, and then on a full-text analysis.

Moreover, we adopted strict criteria to screen papers: according to research aims, we searched exclusively for papers dealing with PV. This selective need brought us to exclude a considerable number of papers from initial search results.

We structured our review following the above guideline and considering articles published from 2000 to 2017 obtaining 2909 articles. A selection based on title and abstract leaded us to a restricted set of 125 articles, which became 71 after a selection based on full text analysis; then, employing citation analysis, we retrieved another 14 articles, achieving a final set of 85 concernig PV. Following paper selection, we developed a categorization considering coding (based on methodology and research purpose) and content criterion (highlighting thematic focuses).

Findings

Literature provides several definitions of PV; nine main thematic areas emerged such as Social Value, Knowledge Value, Innovativeness Value, Portfolio Value, Performance Value, Organizational Value, Economic Value, Customer Value and Strategic Value. In fact, in addition to the tangible and directly calculable benefits, including generated cash flows, revenue, profit and cost minimization, there are a number of intangible benefits, which concern reputation, increased skills and lessons learned (Zhai et al., 2009). In addition, from customer's point of view, PV can be seen in two dimensions: the economic dimension, linked to the price of benefits obtained, and the psychological dimension, that is the combination of those cognitive and affective influences on the purchase of a product/service or the choice of a particular brand (Gallarza et al., 2011).

Subsequently, a model to calculate PV, developed starting from the research results, and a multidimensional index are presented and discussed.

The peculiarity of this index is that it is sum of micro indexes related to the identified thematic areas, discounted by a risk rate.

Originality/value

This research presents and summarizes literature concerning PV. We recognized the most cited and, consequently, most relevant PV elements; thanks to the identification of the above concepts it has been possible to lay the basis for an innovative multidimensional index. The advantages of estimating PV from a multidimensional perspective, typical of project portfolio management, are particularly evident both in project selection and in project evaluation phases.

Research limitations/implications

A theoretical contribution is provided by the systematic review and a practical one by the suggestion of a PV multidimensional index that takes in account the multitude of aspects suggested by literature. This metric can be used for PV estimation in order to support projects implementation decision and/or to evaluate implemented projects.

References

Gallarza, M.G., Gil-Saura, I. and Holbrook, M.B. (2011), "The Value of Value: Further Excursions on the Meaning and Role of Customer", Value. *Journal of Consumer Behaviour*, Vol. 10, pp. 179-191.

Collins, J. A., & Fauser, B. C. J. M. (2005), "Balancing the strengths of systematic and narrative reviews", *Human Reproduction Update*, Vol. 11(2), pp. 103–104

Laursen, M. and Svejvig, P., (2016), "Taking stock of project value creation: A structured literature review with future directions for research and practice", *International Journal of Project Management*, Vol. 34, pp. 736–747.

Macpherson A, Holt R, (2007), "Knowledge, learning and small firm growth: A systematic review of the evidence", *Research Policy*, Vol 36, pp. 172–192.

Pittaway L., Robertson M., Munir, K., Denyer, D. & Neely A., (2004), "Networking and Innovation: A Systematic Review of the Evidence", *International Journal of Management Reviews*, Vol. 5. pp. 137 – 168.

Project Management Institute (2017), "A Guide to the Project Management Body of Knowledge (PMBOK guide 6th Edition), Newtown Square, Pa: Project Management Institute.

Zhai, Li & Xin, Yanfei & Cheng, Chaosheng. (2009), "Understanding the value of project management from a stakeholder's perspective: Case study of mega-project management", *Project Management Journal*, Vol. 40. pp. 99 – 109.

25. Building a Project Mindset: A Canvas for Managing Project Complexity

Gianluca Elia, Alessandro Margherita, Giustina Secundo

The on-going technological and socio-economic transformations are shaping a new scenario in which the competitiveness of organizations stays on the capacity to conceive, design and implement innova-tion processes (Tonchia and Nonino, 2007), thus contributing to shape a "projectified" world where change takes place through project-based processes (Geraldi et al., 2011). Successful organizations are in-creasingly undertaking global multi-stakeholder projects character-ized by sophisticated scope, uncertainty and overall complexity (Archibald, 2016; Ben Mahmoud-Jouini et al., 2016; Padakar and Go-pinath, 2016). The past 60 years have seen the increased use of pro-jects to fulfil the strategic objectives of organisations (Turner, 2010), and projects have been considered as a tool to deal with increasing complexity (Baccarini, 1996), uncertainty (Martinsuo et al., 2014; Huemann and Martinsuo, 2016), and ambiguity in the contemporary socio-economic environment (Bredillet, 2010). Defining and under-standing such complexity, and exploring the elements that underlie the same, are crucial steps for a successful project management (PMI, 2014). Moreover, with a shifting focus from project control to project adaptability, it is today increasingly necessary to develop capabilities to manage complex projects (Bolzan de Rezende et al., 2018).

During the last decade, scholars and practitioners proposed different ways to deal with the structural and environmental complexity of projects by using methodologies, techniques and tools able to support the management throughout the project lifecycle (Capaldo and Volpe, 2012; Kerzner, 2005). Among such methods, the PMBOK (PMI,

2017) describes 49 project management processes organized in 5 groups (initiating, planning, execution, monitoring, and closing) and 10 knowledge areas (scope, time, cost, quality, human resources, communications, risks, procurement, stakeholder, and integration). The APM BOK codifies knowledge related to the management of projects, programs and portfolio by presenting 69 issues organized in 4 sections (context, people, delivery and interface). The PRINCE2 is based on 7 themes, 7 principles and 7 processes (starting, direction, operational execution, control, release of results, management of the transition, and closing), the ICB focuses on 29 individual competencies grouped in 3 areas related to people, practices and perspectives. Finally, the PMAJ BOK highlights the value-oriented dimension associated to the implementation of projects, programs and portfolios, and it is articulated in 11 chapters connected to 11 key project dimensions (Margherita et al., 2018).

Although these methodologies are crucial to develop and apply project management knowledge and skills into experts and professionals, they could somehow represent an undesired level of detail. In particular, the quest for simple rules is a counterintuitive but crucial requirement when the main need is to understand the basic rationale and principles behind the existence of a complex project. Complexity generates uncertainty supporting the need to call for improvisation and causes deviations from the plan (Böhle et al., 2015). The key managerial problem to address is thus the search and adoption of effective and simpler approaches to the identification of crucial project components, with a key research question that orbits two main issues such as "how to define a system view of a project" and "how to visualize and manage project complexity so to streamline management activities". It is accepted that project managers improvise (Leybourne, 2006a; 2006b; 2007; Leybourne and Sadler-Smith, 2006) and that specific techniques for resolving ambiguity and complexity within such projects are required (Cooke-Davies et al., 2007).

In such endeavour, the main goal of this research is to articulate a discussion on projects as constellations of interrelated components, and design a visualization and analysis tool for (project) managers, (potential) entrepreneurs and professionals. The ultimate goal is to contribute to the creation of a project mindset, i.e. an orientation to achieve specific and innovative results by performing well-focused activities based on the use of limited resources. The construction of a project mindset contributes to consolidate the new emerging archetype of T-shaped professionals (Martinez et al., 2016), and is in line with the attempt to reduce management complexity through the development of a systematic project management canvas.

Design/methodology/approach

The research was based on a design science approach (Hevner et al., 2004; Peffers et al., 2006), which includes the steps of problem identification, objectives definition, artefact development, and preliminary solution demonstration and evaluation. Problem was identified by looking at increasing complexity of projects and the deriving limitations or shortcomings of current approaches and methods. The key objective identified was thus to identify the key pillars of project management using a non-expert perspective. Artefact development was carried out by leveraging teaching and research experience of authors, who designed a project management canvas through a bottom-up process. Finally, the framework proposed has been preliminary presented to a group of university students and professionals without any technical background in the project management discipline, during half-day workshops. Data were mostly collected from extant literature of project management methods. Adopting a deductive research strategy (Bryman & Bell, 2015), we moved from the literature on project management to define an interpretative framework and a set of assumptions that the canvas embeds and externalizes.

Findings

The main finding of the research is a canvas for visualizing, describing and managing the project as a complex system. The Project Management Canvas (Margherita et al., 2018) includes 9 key components represented by the project customer, the result to achieve, the stakeholders to involve, the activities to perform, the time to respect, the resources to use, the budget to spend, the value to generate, and the coordination effort among all these elements. Each component includes a number of distinguishing elements and a list of critical success factors associated to a successful implementation. Besides, the research presents a discussion of a dynamic view of project management in terms of components and flows among the same.

The "static" view of a project (i.e. the components) is thus complemented with a dynamic view (i.e. flows). Finally, an outcome of research is represented by a competence framework useful to design and launch competence development initiatives within the project management discipline.

Originality/value

The main originality and value of the article relies on the systematization of project components into a canvas able to support both the visualization and the analysis of project complexity dimensions. The idea of developing a canvas, which has been successfully applied in the study of business models, can be a straightforward approach to support managers, entrepreneurs and other practitioners in the project management domain. Leveraging a visual approach to describing components and relationships, the canvas can stimulate creativity and provide a structured approach useful to codify innovative and sustainable ideas. Expected results can be also envisioned in terms of education practices and learning processes grounded on the canvas and a further input for professionals' associations aiming to systematize project management through new (mental) models.

Practical implications

The Project Management Canvas may be useful to conceptualize a new project or describe an existing project in search of strengths and weaknesses. The visual approach can be used to stimulate creative processes of individuals, teams and organizations, thus resulting in a more "entrepreneurial" project management (Martens et al., 2018). The canvas used as knowledge map may represent a knowledge sharing framework for virtually global project teams, as well as a learning tool to support training and competence development initiatives (Pant and Baroudi, 2008) targeted to both expert and non-expert audiences, as well as to professionals (e.g. scientists, doctors, artists), which are traditionally considered "far" from project management (Ackoff, 2010). The canvas is a tool to streamline and address project complexity and its management.

Research limitations/implications

The framework proposed was preliminary validated using students and professionals without technical background in the field, but not validated into a real-life project setting. An extended evaluation (in terms of number and heterogeneity of actors involved) should be thus planned to investigate and assess the consistence and utility of the canvas in different scenarios of use (e.g. defining of a new project, management of an existing project, improvement of a project draft, etc.).

References

Ackoff RL (2010) *Systems Thinking for Curious Managers*, Axminter, Triarchy.

Archibald RD (2016) *Project Management. La Gestione di Progetti e Programmi Complessi*, FrancoAngeli, Milano.

Baccarini D (1996) The concept of project complexity - a review, *International Journal of Project Management*, 4(4), 201-204.

Ben Mahmoud-Jouini, S., Midler, C., & Silberzahn, P. (2016). Contributions of design thinking to project management in an innovation context. *Project Management Journal,* 47(2), 144–156.

Böhle, F., Heidling, E., Schoper, Y. (2016). A new orientation to deal with uncertainty in projects. *International Journal of Project Management*, 34(7), 1384-1392.

Bolzan de Rezende L, Blackwell P and Pessanha Goncalves MD (2018) Research focuses, trends, and major findings on project complexity: A bibliometric network analysis of 50 years of project complexity research, *Project Management Journal*, 49(1), 42–56.

Bredillet, C. (2010). Blowing hot and cold on project management. *Project Management Journal*, 41(3), 4-20.

Bryman, A., & Bell, E. (2015). Business research methods. 4th edition. New York, SA: Oxford University Press.

Capaldo G and Volpe A (2012) *Project Management: Principi, Metodologie e Applicazioni per il Settore delle Opere Civili*, McGraw-Hill, Milano.

Cooke-Davies T, Cicmil S, Crawford L, Richardson K. 2007. We're not in Kansas Anymore, Toto: Mapping the Strange Landscape of Complexity Theory, and its Relationship to Project Management. *Project Management Journal*, 38(2), 50–61.

Geraldi J, Maylor H and Williams T (2011) Now, let's make it really complex (complicated): a systematic review of the complexities of projects, *International Journal of Operations and Production Management*, 31(9), 966-1090.

Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004). Design science in information systems research. *MIS Quarterly*, 28(1), 75–105.

Huemann, M., Martinsuo, M. (2016). In project management, uncertainty is a great opportunity. *International Journal of Project Management,* 6 (34), 1026-1027.

Kerzner H (2005) *Project Management. Pianificazione, Scheduling e Controllo dei Progetti*, Hoepli, Milano.

Leybourne S.A. (2006a) Managing Improvisation within Change Management: Lessons from UK Financial Services. *Service Industries Journal*, 26(1), 1–23.

Leybourne S.A. (2006b) Managing Change by Abandoning Planning and Embracing Improvisation. *Journal of General Management*, 31(3), 11–29.

Leybourne S.A. (2007) Improvising within management: Oxymoron, paradox, or legitimate way of achieving? *International Journal of Management Concepts & Philosophy*, 2(3), 224–239.

Leybourne S.A. (2009) Improvisation and agile project management: a comparative consideration. *International Journal of Managing Projects in Business*, 2(4), 519–535.

Leybourne S.A., Sadler-Smith E. (2006) The Role of Intuition and Improvisation in Project Management. *International Journal of Project Management*, 24(6), 483–492.

Margherita A, Elia G and Secundo G (2018) *Project Management Canvas: Una Guida Operativa per Gestire i Progetti con Successo*, Franco Angeli, Milano.

Martens, C. D. P., Machado, F. J., Martens, M. L., & de Freitas, H. M. R. (2018). Linking entrepreneurial orientation to project success. *International Journal of Project Management,* 36(2), 255-266.

Martinez, M., Di Nauta, P., & Merola, B. (2016). Dynamic Capabilities and T-Shaped Knowledge in Project Management. A Viable Systems perspective. *Governing Business Systems. Theories and Challenges for Systems Thinking in Practice*, 41.

Martinsuo, M., Korhonen, T., Laine, T. (2014). Identifying, framing and managing uncertainties in project portfolios. *International Journal of Project Management*, 32(5), 732-746.

Padakar M and Gopinath S (2016) Are complexity and uncertainty distinct concepts in project management? A taxonomical examination from literature, *International Journal of Project Management*, 34, 688-700.

Pant I and Baroudi B (2008) Project management education: The human skills imperative, *International Journal of Project Management*, ***26***(2), 124-128.

Peffers, K., Tuunanen, T., Gengler C. E., Rossi, M., Hui, W., Virtanen, V., & Bragge, J. (2006). The design science research process: A model for producing and presenting information systems research. In *Proceedings of the First International Conference on Design Science Research in Information Systems and Technology* (DESRIST 2006), 83-106

PMI - Project Management Institute (2014) *Navigating Complexity: A Practice Guide*, PMI, Newton Square, PA.

PMI - Project Management Institute (2017) *Guide to the Project Management Body of Knowledge – 6th edition (Guide to the PMBOK®)*, PMI, Newton Square, PA.

Tonchia S. and Nonino F. (2007) *Project management. Gestire l'innovazione nei prodotti e nei servizi*, Sole24Ore, Milano.

Turner, J. (2010). Evolution of project management research as evidenced in the International Journal of Project Management. *International Journal of Project Management*, 28(1), 1-6.

List of Authors

Participating Institutions

Agenzia Confederale dei Trasporti e Servizi:

- Ezio Civitareale

Azimut Benetti Group S.p.A. - Benetti Yachts:

- Francesco Ricci

Delft University of Technology – Department of Materials, Mechanics, Management and Design:

- Marcel Hertogh
- Erik-Jan Houwing
- Huimin Liu
- Yan Liu

DXC Technology:

- Vincenzo Arnone

Istituto Nazionale di Statistica (National Statistics Institute) – Division for Strategic Planning:

- Silvia Losco

Link Campus University of Rome - Department of Research:

- Stefano Armenia

Politecnico di Milano – School of Management:

- Tommaso Buganza

Politecnico di Torino – Department of Management and Production Engineering:

- Alberto De Marco
- Paolo E. Demagistris
- Giulio Mangano

Project Management Institute:

- Marco Arcuri
- Edoardo Favari

Sapienza University of Rome - Department of Civil, Constructional and Environmental Planning:

- Antonio Fioravanti
- Gabriele Novembri
- Francesco Livio Rossini

Sapienza University of Rome - Department of Computer, Control and Management Engineering:

- Alessandro Annarelli
- Alessandro Avenali
- Giorgio Matteucci
- Fabio Nonino
- Giulia Palombi
- Alessandro Pompei

Sapienza University of Rome – Department of Management:

- Cristina Simone

Sapienza University of Rome - Department of Mechanical and Aerospace Engineering:

- Francesco Costantino
- Giulio di Gravio
- Riccardo Patriarca
- Massimo Tronci

SDA Bocconi School of Management - Leadership, Organization and HR Management Knowledge Group:

- Marco Sampietro

Solvay Business School - Executive Education:

- Antonio Nieto Rodriguez

Technical University of Bari - Department of Mechanical and Management Engineering:

- Nunzia Carbonara
- Roberta Pellegrino

The Business Game S.r.l.

- Nicola Baldissin
- Simone Magrin

Trenitalia S.p.A.:

- Gianna Di Gaetano
- Valeria Salvia

University of Bari - Department of Computer Science:

- Maria Teresa Baldassarre
- Vita Santa Barletta
- Danilo Caivano

University of Bergamo – Department of Management, Information and Production Engineering:

- Matteo Kalchschmidt

University of Calabria – Department of Informatics, Modelling Electronics and Systems Engineering:

- Alfredo Garro

University “Campus Bio-Medico” of Rome - Department of Engineering:

- Pierangelo Afferni

Università Cattolica del Sacro Cuore – Department of Economics and Social Sciences:

- Franca Cantoni

University of Pisa - Department of Energy, Systems, Territory and Construction Engineering:

- Davide Aloini
- Annamaria Diprima

University of Rome Tor Vergata - Department of Enterprise

Engineering:

- Elisabetta Benevento

University of Salento – Department of Engineering for Innovation:

- Gianluca Elia
- Alessandro Margherita
- Giustina Secundo

University of Salerno - Department of Management and Innovation Systems:

- Antonio La Sala

University of Siena - Department of Information Engineering and Mathematics:

- Cinzia Battistella

University of Trento - Department of Industrial Engineering:

- Andrea Molinari
- Michele Urbani

University of Udine - Polytechnic Department of Engineering and Architecture:

- Alberto F. De Toni
- Simone Gitto
- Elena Pessot

Collana Convegni

Per informazioni sui precedenti volumi in collana, consultare il sito:
www.editricesapienza.it

20. Giorgio Bazzichelli. L'uomo e lo scienziato
Autori vari
21. Attuazione e sostenibilità del diritto alla salute
Roberto Nania
22. Épicurisme et Scepticisme
Stéphane Marchand & Francesco Verde
23. I musei di chimica e la chimica nei musei della scienza
Luigi Campanella e Valentina Domenici
24. Digital Humanities
Progetti italiani ed esperienze di convergenza multidisciplinare
Fabio Ciotti
25. Atti della Giornata in ricordo di Federico Caffè
Mario Tiberi
26. Information Technologies for Epigraphy and Cultural Heritage
Proceedings of the First EAGLE International Conference
Silvia Orlandi, Raffaella Santucci, Vittore Casarosa, Pietro Maria Liuzzo
27. Oltre i confini
Studi in onore di Giuseppe Burgio
Raimondo Cagiano de Azevedo, Claudio Cecchi, Angela Magistro
Giorgio Milanetti, Giuseppe Sancetta, Donatella Strangio
28. Novità nella ricerca archeologica a Veio
Dagli studi di John Ward-Perkins alle ultime scoperte
Roberta Cascino, Ugo Fusco, Christopher Smith
29. La letteratura e il male
Atti del Convegno di Francoforte, 7-8 febbraio 2014
Gianluca Cinelli e Patrizia Piredda
30. La Facoltà di Scienze dell'Università di Roma
dall'Unità alla prima guerra mondiale
Giornata di lavoro e discussione
Enrico Rogora
31. Paul Celan in Italia
Un percorso tra ricerca, arti e media 2007-2014
Atti del convegno (Roma, 27-28 gennaio 2014)
Diletta D'Eredità, Camilla Miglio, Francesca Zimarri

32. Per un *corpus* dei pavimenti di Roma e del Lazio
Atti della Giornata di Studi, Roma 24 novembre 2014
Sapienza Università di Roma
Claudia Angelelli e Stefano Tortorella

33. Europa Concentrica
Soggetti, città, istituzioni fra processi federativi e integrazione politica dal XVIII al XXI secolo
Alessandro Guerra e Andrea Marchili

34. Edizioni Critiche Digitali/Digital Critical Editions
Edizioni a confronto/Comparing Editions
Paola Italia e Claudia Bonsi

35. La famiglia da concepire
Il benessere dei bambini e delle bambine con genitori gay e lesbiche
Roberto Baiocco, Nicola Carone, Vittorio Lingiardi

36. Digital and Traditional Epigraphy in Context
Proceedings of the EAGLE 2016 International Conference
Silvia Orlandi, Raffaella Santucci, Francesco Mambrini, Pietro Maria Liuzzo

37. I Filosofi del diritto alla 'Sapienza' tra le due Guerre
Atti del Convegno Internazionale Roma, 21 e 22 ottobre 2014
Gianpaolo Bartoli

38. Critica clandestina?
Studi letterari femministi in Italia
Atti del convegno - Sapienza Università di Roma, 3-4 dicembre 2015
Maria Serena Sapegno, Ilenia De Bernardis, Annalisa Perrotta

39. REMSHOA
l'Italia, la Shoah, la memoria. La deportazione degli ebrei in Grecia
Luca Micheletta

40. Human Nature
Anima, mente e corpo dall'antichità alle neuroscienze
Nunzio Allocca

41. The state of the art of Uralic studies: tradition vs innovation
Proceedings of the 'Padua Uralic seminar' - University of Padua, November 11-12, 2016
Angela Marcantonio

42. La didattica del cinese nella scuola secondaria di secondo grado.
Esperienze e prospettive
Alessandra Brezzi e Tiziana Lioi

43. Project Management. Driving Complexity
PMI® Italian Academic Workshop
Fabio Nonino, Alessandro Annarelli, Sergio Gerosa, Paola Mosca, Stefano Setti

Convegni

▸ Scienze e Tecnologie

Contemporary organizations are undertaking increasingly complex projects in globalized, uncertain and dynamic environments. Proliferation of international programs, growing and challenging sophistication of technologies and of projects' scope, and the increasing number of stakeholders are only some of the factors that increase or generate project complexity. Enhancing the understanding of what project complexity is and delineating the antecedents that increase or generate complexity can be fundamental steps towards the identification of drivers that cause complexity and consequences for project management performance.

The PMI® Italian Academic Workshop, organized in 20-21 September 2018 by Sapienza University of Rome and the three Italian Chapter of the Project Management Institute, has been an event aimed at supporting participants to develop their researches to a further stage through in-depth discussions on the topic of project complexity.

Fabio Nonino, Associate Professor of Project Management at Sapienza University of Rome, director of Masters and post-degree courses in Project Management, author of more than 100 scientific publications.

Alessandro Annarelli, Post-Doc Researcher in Management Engineering at Sapienza University of Rome on the topics of Project Management, Servitization and Organizational Resilience.

Sergio Gerosa, President of PMI Central Italy Chapter, director of Operational and Forecast Planning in Thales Alenia Space, lecturer in Universities and Business Schools and author of a book and publications on Project and Program Management.

Paola Mosca, President of PMI Southern Italy Chapter, teacher, consultant, business and life coach, worked for more than 35 years in the ICT field, managing projects and resources at a national and international level.

Stefano Setti, President of PMI Northern Italy Chapter, with extensive experience in ICT and Business Organization, consultant and coach of Project Management and Innovation, author of books and lecturer at University of Parma.

In collaboration with the PMI® Italy Chapters.

ISBN: 978-88-9377-086-6

9 788893 770866

www.editricesapienza.it