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Relationships between Leadership and Success in Different Types of Project Complexities

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Abstract

We investigate the moderating effect of project complexity on the relationship between leadership competences of project managers and their success in projects. Building on existing studies in leadership and project management we assess the impact of emotional (EQ), intellectual (IQ) and managerial (MQ) leadership competences on project success in different types of project complexities. A cross-sectional survey using the Leadership Dimensions Questionnaire (LDQ) and project results questions yielded 119 responses, which were assessed for their type and level of complexity, measured as complexity of fact, faith and interaction. Analysis was done through factor analysis and moderated hierarchical regression analysis. Results show that EQ and MQ are correlated with project success, but are differently moderated by complexity. The relationship between EQ and project success is moderated by complexity of faith. The relationship between MQ and project success is moderated by complexity of fact and faith. Complexity of interaction has a direct effect on project success. ANOVA and non-parametric tests showed the means and medians of EQ, IQ, MQ, complexity of faith, fact and interaction do not significantly vary across different project types. This suggests using these three complexity types as a common language to research and learning across different project types.

Keywords: project management, leadership, project success, emotional intelligence

Managerial relevance

This article contributes to practice in three ways. Firstly, it allows engineering managers to advance their practices for assigning suitable (best-fit) project managers to projects, depending on project manager leadership competences and project complexity. The paper contributes the next level of detail to the current debate on project manager to project fit [4], [79]. The results from the present study allow HR managers to recruit or develop project managers to link personality and project type appropriately in order to improve project performance and ultimately organizational performance [16].

Secondly, the study provides a statistically tested model to assess the context of projects in terms of project complexity. Engineering managers can apply the model to identify the idiosyncrasies of the complexities of their particular projects and subsequently chose best-fit leaders for their projects.

Thirdly, we have analyzed the differences between engineering projects and IT and organizational change projects in respect of complexity measurements. Commonalities across project types indicate that the types of complexity have the potential to act as common language across industries and project types, or at least within the types and sectors analyzed, thus, facilitating cross-industry knowledge sharing and learning.

I. Introduction

Over 60 years of research has brought insight into the management of projects [1], but still only a fraction of projects finishes successfully [2]. This indicates the need to further explore factors influencing project success. Acknowledging that 'one size does not fit all', a series of studies have been conducted to understand the match between project characteristics and appropriate success factors [3]. One important factor is the leadership exercised by the project manager [4], [5]. While the importance of leadership for organizational success has long been recognized as a success factor for organizations, it was not until recently that this concept was adopted and empirically researched in the context of projects [6]-[8].

Our study engages with this conversation and contributes to two gaps. Firstly, we content that earlier studies often substituted team roles, such as Myers-Briggs [9] or Belbin [10] as a measure for leadership. These measures are, however, only weakly related to leadership performance [11], [12], and not related to the project manager's personality in his or her role as a leader. Our study sets out to redress this by applying a framework for leadership competences, measured as intellectual, managerial and emotional competences (IQ, MQ, EQ respectively) developed by Dulewicz and Higgs, as reported in [13]. The framework encompasses both managerial and leadership qualities recognized as important for the management of projects.

The second gap relates to how we consider the context of projects. Previous studies looked at leadership in projects regardless of context and type, for example [14], [15], or considered only technical aspects of the project [8], missing the organizational and commercial dimensions. Turner and Müller, in [4] and [16], observed that complexity is a good indicator of context, but did not define complexity. The present study adds to the work of Turner and Müller by investigating the nature of different types of project complexities and their possible moderating effect on the relationship between leadership and project success. The unit of analysis is the project manager in projects of different types of complexity. The study follows Gell-Mann [17], who claims that one concept of complexity is not enough to explain our perceptions and interactions with a phenomenon, and clustering aspects of complexity is helpful to appraise a subject, and consequently enables a "genuine science" of complexity [18].

We explore the context of projects by looking at different facets of complex projects and how the context moderates the relationship between leadership competences of project managers and project success. We therefore ask:

> *How does project complexity influence the relationship between project managers' leadership competences and project success?*

The results of the study will allow for better identification of suitable project managers for projects with different types and degrees of complexity, which provides for better project results. Results can also be used for the development of individual training programs for project managers.

The paper's contribution to engineering management lies firstly in the recognition that processes are essential to success of non-repetitive operations, but it is people that make these processes work. With Malach-Pines et al [8], we focus on people and environment fit and bring the literature on leadership to the engineering arena. A second contribution is the development of complexity as a form to understand project contexts and its challenge. This variable has the potential to provide a common language to characterize projects. Today the research on projects remains disjoined in the different sectors, e.g. IT, NPD, capital goods, etc. Looking at the complexity of projects can allow for cross-fertilization of learning from different sectors. This is explored in the present article.

II. Literature review and hypotheses

In the following section we briefly review the related literature on project success, leadership and complexity. Subsequently we develop the research hypothesis before we finish the section by outlining contingency theory as the theoretical perspective of the study.

A. Project success

Although the iron triangle (time, cost, quality) remains the predominant understanding of project success among practitioners [19], projects such as Sidney Opera challenge such concepts of success. The project was expected to finish in four years and cost $7 million, instead it took 14 years and cost over $100 million. Yet, it is considered a successful project, as it became the icon of Australia.

Scholars like Atkinson, [20], Shenhar and Dvir [3], or Cicmil and Hodgson [21] propose a widening of the iron triangle perspective, mainly into the realm of supplier and stakeholder satisfaction. Along these lines Collins and Baccarini [19] suggest to extent the iron triangle by including a product success criterion of meeting project owners' needs. Among the most often cited works on the measurement of success are those by Shenhar et al. [86], Hoegl and Gemuenden [87], Pinto and Slevin [88], who propose different measurement models for either different aspects of project success or different project types. Appendix 1 shows the measurement dimensions used in these works, as well as some of the recently used measurement models. Among those the model by Turner and Müller [16] was chosen because it allows a) for a good balance between soft and hard factors of project success measure, b) the project to define its own success criteria, and c) to be consistent in approach (this study is a continuation of the Turner & Müller study). The model consists of the iron triangle (criteria 5 below) plus nine other success criteria to assess project managers' achievement of:

1. End-user satisfaction
2. Supplier satisfaction
3. Team satisfaction
4. Other stakeholders' satisfaction

5. Performance in terms of time, cost, quality
6. Meeting user requirements
7. Project achieves its purpose
8. Customer satisfaction
9. Reoccurring business
10. Projects' self defined success criteria

Five of the success criteria assessed the 'satisfaction' of different stakeholder groups (criteria 1-4 and 8). The remaining criteria assessed more objective criteria, such as meeting of requirements, delivering on time, cost and quality, including possible criteria defined by the project itself.

The aspects influencing success range from process (e.g. [22]), via people (e.g. [5], [8], [23]) to context (e.g. [3], [24]). The present research focuses on the influence of the last two and their interrelationship, specifically leadership and complexity.

B. Project manager leadership competence

The effect of the human dimension on project success was first shown by Pinto and Slevin [25] and was continued among others by Cooke-Davies [22] and Westerveld [5]. Cooke-Davies [22, pp. 189] concluded *"It is not as if there are some [success] factors that involve processes, and others that involve people—people perform every process, and it is the people who ultimately determine the adequacy."*

One of the important soft-success factors is the role of the project manager as a leader, as opposed to manager. This is confirmed in R&D projects but still under-researched in other sectors, such as construction and IT projects [26]. According to Bennis and Nanus [27], managers bring about, accomplish, have responsibility for and conduct, while leaders influence, guide in direction, course, action, and opinion. They define this distinction as crucial, because managers are those who do things right and leaders are those who do the right things [27].

Leadership is one of the classic themes in the social sciences and management, and counts with extensive history and several schools of thought. The trait school (e.g. in [28]) claimed that successful leaders are borne leaders and share common traits. The behavioral school (e.g. [29]-[31]) assumed that some aspects of leadership can be developed. The contingency school [e.g.in [32]) argued that there are different types of leadership suitable to different contexts. Thereafter, the relational school studies continued exploring the context of leaders but in terms of their relationships with other members of the organization, today mainly represented by investigations on Leader-Member-Exchange (LMX), (see [33] for a review in this area). The next schools further developed the concept of leadership but continued to accept the importance of fit between context and leadership styles.

The visionary or charismatic school (e.g. [34]) emerged from research in organizational change, and distinguished between transactional and transformational leadership styles. Keegan and Den Hartog [35] took this school into project management. They predicted a preference among project managers for the transformational style. However, they could not find significant evidence for it. Based on their research on leadership in successful versus less successful projects Turner and Müller [16] concluded that transformational style is preferred on complex projects, like organizational change projects; and transactional style on more simple projects, like the construction of a house.

The emotional intelligence school continued the trend of the former schools by moving from an understanding of leadership as being visible and observable to one of being relational and interactional. The emotional intelligence school as understood by Goleman [36] distinguishes between personal competences (self awareness and self management) and social competences (social awareness and relationship management). It focuses on the abilities of leaders to read the emotions in themselves and their followers and act wisely in their relation with others.

The competency school, as the most recent of these schools, integrated aspects of all the previous leadership theories and clustered them under emotional (EQ), managerial (MQ) and intellectual (IQ) competences [37]. The competence school recognized that in the daily work of managers, both sustainable and high success of managers requires good leadership and management capabilities [38] and therefore managers require IQ, MQ and EQ. Dulewicz and Higgs [39] showed that these competencies predict a large amount of variation (71%) in leaders' performance.

It is reasonable to expect that this bond of competences is important to manage projects. Project managers critically evaluate plans and actions, and provide direction (IQ), at the same time they build and maintain the relationship with those being led (MQ) and demand emotional resilience to respond to unexpected events and stress often present in projects (EQ). Turner and Müller [16] applied the competence school to project managers and showed the link of EQ, MQ and IQ with success in different types of projects. Here EQ was related to success in almost all types of projects, MQ was related to success in engineering projects with fixed price contracts, only a specific dimension of IQ, vision, was inversely related to success in most projects.

Although the hypothesis put forth by situational leadership is widely recognized, the link between leadership competences and the challenge faced by project managers remains under-researched. This link is further explored in the next sections.

C. Complexity in projects

To our knowledge, only a few studies examined the fit between project manager leadership styles and types of projects. Two recently published exceptions constitute the basis of our work. The first, authored by Malach-Pines et al. [8], studies the fit between project manager and project in an array of industries, including defense, agriculture, high-tech, chemistry and construction and differentiate them according to four variables: complexity, technology, pace, and novelty. These aspects are highly technical, and do not embrace the rather soft challenges embedded in projects, such as the nature of the relationship with stakeholders, the dynamics during project execution, the number of countries and languages involved, etc. Thereby it is reasonable to expect that leading in such contexts draws on some attributes of leadership, such as emotional resilience in case of difficult negotiations and the ability to communicate clearly when dealing with international audiences. The complexity framework used in this study accounts for at least some of these factors. In particular, it adds people related aspects, which were not considered in the study mentioned above.

Another exception is Turner and Müller [4], [16], who also showed a strong empirical relationship between project success and the project managers' leadership competences in different types of projects but in a cross-sector study. They defined the context of projects by their type (engineering, IT or organizational change), strategic importance, contract type and complexity. Their research indicated that leadership competences, measured as IQ, MQ, EQ – (further described in Appendix 2) are correlated differently with project success, depending on the project being perceived to be low, medium or high in its complexity.

Assuming that people's classification of complexity is individually constructed [41] and vague [42] the need arises to better understand and define the complexities present in projects and the relationship between these and leadership in successful projects.

Complexity also emerged as a concept to understand some of the difficulties encountered in project contexts, and has received increasing attention of academics and practitioners [43]-[45]. The work in this area has taken a step back from the analysis of factors leading to project success or failure, and looked at the challenges project managers face. This provides a different understanding of project contexts, more granularly than previous typologies.

Historically, the ways complexity has been characterized include:

- a large number of elements [46] or variables [47]
- indirect communication among elements [48]
- heterogeneity of these elements and the variety of these relationships [41], [47] and [49]
- variety and variability (e.g. [50], [51])

Under the umbrella of complexity theories [52], other authors explored behaviors of complex systems, such as emergence, positive feedback loops, self-regulation, irreversibility, unpredictability, among others [53] - [55].

The explicit study of complexity in projects started in the 1990s. Payne [56] defined complexity based on a study on the multiple interfaces of projects. Baccarini [57] defines complexity as projects consisting of many varied interrelated parts, and operationalizes the concept in terms of organizational and technological differentiation and interdependency. Williams [58] distinguished two complexities: the randomness (or uncertainty) and the structural complexity. Shenhar and Dvir [3], and Shenhar [59] indirectly approached this subject when proposing the typology of projects based on technological uncertainty and system scope, as the higher the technological uncertainty and the higher the system scope are, the more significant are the randomness and structural complexity, respectively. In a recent paper, Dvir et al. [6] renamed system scope to complexity, and added two other dimensions: pace and novelty. These remain closely correlated with the two groups of complexity defined above, namely randomness and structural complexity.

Turner and Müller [16] interviewed managers of project managers and asked them to define the characteristics of complexity in projects. The most often mentioned were size of the project; number of departments involved; number and type of stakeholders; location; form of contract. Crawford et al. [60] identified eleven characteristics of complexity: project scope; number of sites, locations, countries; number of functions or skills; organizational involvement; clarity of goals; level of ambiguity/uncertainty; risk source and location; technical complexity; individual or component of large project; familiarity; organizational impact.

By integrating most of these views Geraldi and Adlbrecht [62][1] developed the concept of "Patterns of Complexity", which expands the typology proposed by Williams [58] in defining three types of complexity:

- Complexity of Faith: similar to uncertainty, this complexity is present when creating something unique, solving new problems or dealing with high uncertainty. In such situations, one does not know that the project outcome will work, but has, or at least pretends to have, faith in it. For example, the development of a new drug, where the outcome and processes are uncertain, especially in the conceptualization phase.
- Complexity of Fact: similar to structural complexity, this requires dealing with a huge amount of interdependent information. Here the challenge is to keep a holistic view of the problem and not to get lost in quantities of factual details. The construction of a refinery is a project dominated by such complexity, there are many constraints to consider, and many people involved, but these are not uncertain, they are 'facts'.
- Complexity of Interaction: usually present in interfaces between locations/humans and characterized by transparency, multiplicity of reference and empathy. Organizational change is dominated by such complexity, where interests of the parties

[1] More details on the methodology of Geraldi and Adlbrecht [62] in the methodology section.

are often unclear and conflicting, and the relationship between people, persuasion, and empathy play an important role.

Appendix 3 provides a summary of the characteristics of complexities as proposed in the literature, and a cross reference to the model of Geraldi [61] and Geraldi and Adlbrecht [62]. This model comprises most of the characteristics of complexity published so far.

Summarizing, we propose a theoretical framework that defines complexity as a multidimensional construct, stemming from the trust in the ability to produce the project's outcome, the amount of information to be processed, dynamic and uncertainty engrained in projects, and the interaction of the actors involved, including both personal and political layers.

Williams [89] sees these complexities as interdependent, for example, the low transparency in the relationship between parties may intensify the uncertainty of the project and even lead to changes. Intuition might even suggest that coexistence of different types of complexity may intensify the overall intensity of complexity, e.g. it might be more complex to cope with high complexity of faith (e.g. constant and high impact changes) when one would also have high complexity of interaction (low transparency and empathy among project stakeholders). This would have implications on the calculation of complexity. We should consider determining an overall complexity rather by multiplying complexity degrees instead of simply averaging complexities. However, the nature of the interrelationship between these types of complexities was not studied previously. Certain combinations could actually not have such cascade effect on the overall complexity, and it would be not more than a guess. Thus, although recognising that the types of complexity are interdependent, it is exactly the complex nature of its interdependence that motivated us to consider them as additive, that is, averages instead of multiplications.

Project complexity is therefore a particular and unique combination of emotional, intellectual and managerial challenges. Complexity of faith relates to uncertainty in project outcomes, thus the emotional assessment of the project situation in terms of the EQ dimensions of the competency school (listed in Appendix 2). Complexity of fact relates to the simultaneous processing of large amounts of data and data sources. From a leadership competency perspective, this is addressed through the rational capabilities of the project manager, thus the

IQ dimensions of the competency school. Complexity of interaction is about communication and personal interaction styles of managers and is therefore mirrored in the MQ dimensions of the competency school.

The literature review above showed a lack of theory on the relationship between project manager leadership style and success in projects of different complexities. However, it implies the existence of such a relationship and its possible impact on the success of projects. As complexity may have direct influence on success, and previous studies showed that leadership impacts success significantly [4], [16], complexity may function as a *moderator*, that is, a variable that impacts the nature and the strength of the EQ, IQ and MQ relationship with project success [40]. We therefore address our research question and hypothesize that:

H1*: Project complexity has a significant moderating effect on the relationship between leadership competences and project success.*

Figure 1 shows the associated research model, with the leadership competences as independent variable and project success as dependent variable. The relationship is moderated by project complexity.

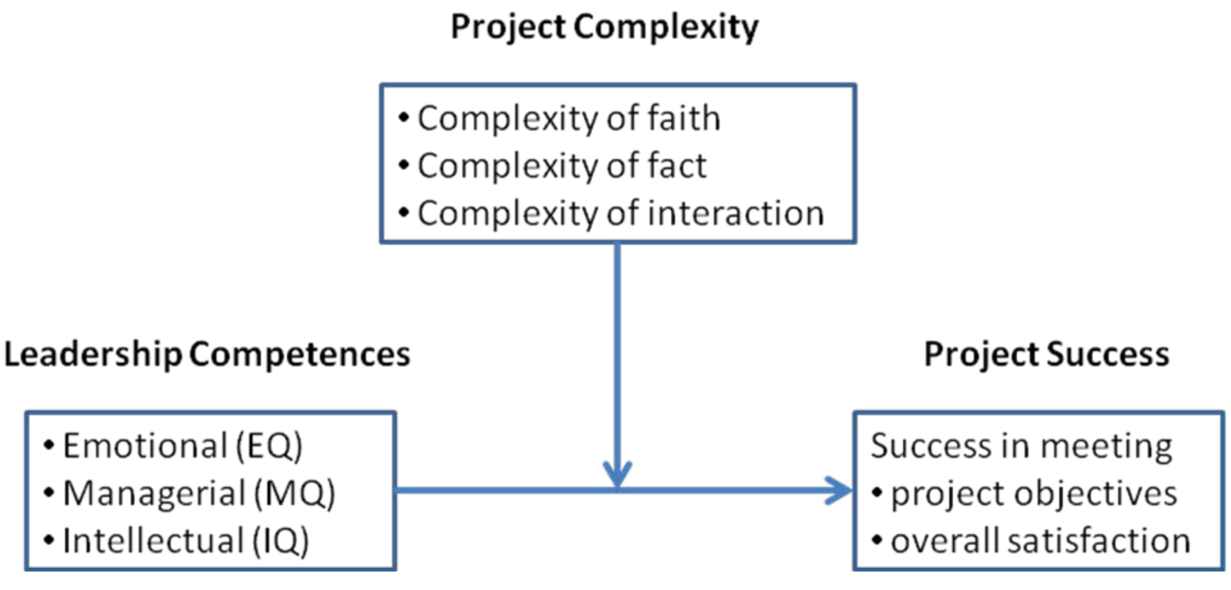

Figure 1: Research model

D Contingency theory as theoretical perspective

The aim of this research is to understand the impact of leadership competences on project success in the context of different types of complexity. An appropriate theoretical lens for this is contingency theory, which claims that context and organizational design factors must somehow fit together for organizations to perform well [80]. Early versions of contingency theory [e.g. 81] claimed that context shape organizational design factors, whereas later versions introduced reflexivity and allowed for interactions between context and organizations, thus aiming for organizational adjustment to regain fit with its context [82], which assumes that the ultimate cause of change is a change in the contingency variable. This led to the emergence of moderator models and related analysis techniques that take into account interaction effects between the phenomenon under study and its context [80], such as hierarchical regression analyses.

Specific types of contingency theories are the popular person-environment fit (P-E fit) theory, or person-organization fit (P-O fit) theory [8]. They refer to the fit between characteristics and expectations of people with that of organizations. These theories have only recently being explored within the operations management literature and specifically in projects as temporary organizations [8]. Here they developed into a popular theoretical perspective. Most prominent representative may be the “value of project management” study, which also claims the need for a fit between project and its context [83].

III. Methodology

By applying a P-E fit theory perspective we used a deductive, positivistic approach and addressed the project managers through a web-based questionnaire, to assess the project complexity and success of their last completed project. We obtained 136 responses of which 119 were usable and analyzed them by using:

- Factor analysis to verify and further develop the measurement scales
- Hierarchical regression analyses to test the hypothesis
- ANOVA and Mann-Whitney tests to test for differences by project type

A. *Sample*

The questionnaire on complexity was applied to projects and their managers from the sample of 400 project managers of Müller and Turner's [4] prior study on Leadership. These were members of the Project Management Institute (PMI®), International Project Management Association (IPMA) and other professional organizations for project managers. After a pilot test of the questionnaire, project managers were contacted using email with a link to the web-survey. 120 email addresses of the original sample were no longer in use, which reduced the sampling frame to 280. 136 of those answered the survey, a response rate of 48.6%. Forty-two responses were received in the first week, 51 after the first reminder and 31 after the second reminder. 119 of the 136 responses could be used for analysis and reconciled with the respondents original sample data on EQ, MQ, IQ, project type, and project success from Turner and Müller [16]. ANOVA analysis was performed to assess the non-response bias on early versus late wave of respondents (those responding after the reminder) using overall success and one indicator of each type of complexity (average empathy with stakeholders, size and uniqueness). The results of the Levene tests were insignificant ($p>.05$), indicating no differences between the groups.

Minimization of mono-source bias, due to self rated performance, was addressed in several ways within the initial questionnaire by Turner and Müller [16]. For example through a variation of Podsakoff et al's [63] and Conway and Lance [64] suggestions, like confirmed anonymity in the introductory text and clarification that there are no right or wrong answers. Two different surveys with different layout and scales were used. The first survey resided on a server in Sweden and asked for project complexity, characteristics and success, the second survey resided on a server in the UK and assessed the leadership competencies of the respondent. A factor analysis of the 15 leadership competencies variables and the nine success variables showed that leadership variables loaded on the first factor and success measures on the second factor (at cut-off = .5), except for Intuitiveness (a leadership competency) and the success measure Reoccurring Business, which both loaded on their own factor. Mono source bias was therefore assumed not to be an issue.

The survey was based on a critical incident approach. To avoid biases introduced by the choice of the project, such as the possibility of respondents providing data only about the most successful project, the survey asked respondents to report about their most recently completed project. As the project was already completed, we avoided optimism bias in estimation of the project success.

In the present sample the majority of the respondents were from North America (56%), male (69%), working in the private sector (59%), and certified project managers (66%). Details are given in Table 1.

Characteristic	*N*	*%*	*Characteristic*	*N*	*%*
Sector			**Geography**		
Private	73	61.3	North America	62	53.4
Public	37	31.1	Europe	21	18.1
Not for profit	6	3.0	Australasia	17	14.7
Total	116	95.4	Other	16	13.8
Missing	3	4.6	Total	116	100.0
Project type			**Age**		
Eng	10	8.4	≥ 35	8	6.5
IT	44	37.0	36-40	18	14.5
Org Change	20	16.8	41-45	20	16.1
Combined Eng and IT	2	1.7	46-50	32	25.8
Combined Eng and Org Change	4	3.4	51-55	18	14.5
Combined IT and Org Change	29	24.4	<55	19	15.3
Combined Eng, IT and Org Change	4	3.4	Total	115	92.7
Total	116	97.5	Missing	9	1.7
Missing	3	2.5			
Project size			**Certification**		
< $50mi	70	58.8	Non-certified	32	26.9
From $50 to $200mi	36	30.3	Certified	82	68.9
> $200mi	8	6.7	Total	114	95.8
Total	114	95.8	Missing	5	4.2
Missing	5	4.2			
Education					
First degree	30	25.2	**Gender**		
Higher degree	35	29.4	Male	78	69.4
Professional qualification	48	40.3	Female	38	30.6
Total	113	94.9	Total	116	97.5
Missing	6	5.1	Missing	3	2.5

Table 1: Sample demographics

B. Preparation and operationalization of variables

1) Leadership

Operationalization of the leadership competences was done using a standard tool of the competency school of leadership, the Leadership Dimensions Questionnaire (LDQ), developed by Dulewicz and Higgs in [13]. The questionnaire was developed from their earlier work in [11] and [65] and validated through a study of over 400 line managers [37], [39]. Three further studies, including [15], [66] and [67], applied the instrument to determine the leadership profile of over 600 officers from the Royal Navy and Royal Air Force, substantially increasing the number of data points and further validating the instrument. Since then a number of further studies were done using the LDQ. Indeed Young and Dulewicz [67] compared the LDQ to another instrument, the Occupational Personality Questionnaire (OPQ), and found that the LDQ was better at predicting leadership performance.

The LDQ contains 187 (mainly Likert scale) questions, to assess fifteen leadership competences grouped into the three competence areas, Intellectual (IQ, three competencies), Managerial (MQ, five competencies), and Emotional (EQ, seven competencies). Definitions of the fifteen LDQ competencies are presented in [37] and listed in Appendix 2. The questions in the LDQ are in random order, so the respondent does not know the nature of the particular questions being answered, thereby reducing bias.

Leadership competences were calculated for EQ, MQ and IQ as the mean of the underlying measurement dimensions assessed using the LDQ. Reliability levels for IQ and MQ are satisfactory (alpha of 0.79 and 0.86 respectively). With a reliability of 0.63 EQ is lower than Dulewicz and Higgs' [37] results of > 0.7. Therefore we analyzed the factor loadings for each variable and identified that sensitivity and intuition had very low values, .038 and -.07 respectively. We eliminated these two variables, and the reliability level increased to 0.760. Table 3 shows further details.

2) Complexity

Operationalization of complexity of faith, fact and interaction was based on the qualitative model of Geraldi and Adlbrecht [62]. The questions, twelve in total, were originally developed, reviewed and validated through 47 interviews with six German Plant Engineering companies and an in-depth study in one of them (further described in [61], [62]). The questions were:

1. Complexity of faith:
   - C1. Perceived immaturity of the project
   - C2. Frequency of technical scope changes
   - C3. Magnitude of impact of these changes
   - C4. Uniqueness of the project (i.e. new client, technology, partner, etc)
2. Complexity of fact
   - C5. Amount of information to be processed
   - C6. Number of people and organizations involved
   - C7. Interdependency of technology, people and organizations
   - C8. Characteristics of the project (size)
3. Complexity of interaction
   - C9. Level of internationality
   - C10. Level of multi-disciplinarity
   - C11. Degree of transparency of information
   - C12. Empathy with stakeholders

Operationalization was done by using seven point Likert scales ranging from very low to very high. Some aspects of complexity are expected to change in the course of the project [62] and therefore we assessed the three types of complexity (faith, fact, interaction) per project phase. Five project phases were considered, feasibility, design, execution and control, close out, and commissioning. Exceptions for these were C4 (uniqueness) and C8 (size), which are expected to be constant throughout the live cycle of project (as in studies of e.g. Shenhar and Dvir), and C11 (transparency) and C12 (empathy) which is expected to vary according to stakeholder, for example, the transparency among members of the team tends to be different than with clients or suppliers.

For the development of the measurement scales for project complexity, we summarized the responses by project phases of each variable of complexity by taking the mean of the five project phases. This step was supported by high Cronbach Alpha of complexity variables (ranging from 0.80 to 0.97), which indicate a high degree of consistency between the multiple measurements of a variable [68].

Subsequently a confirmatory factor analysis was done to validate the measurement scales of the complexity questions. The scales were not fully supported quantitatively with the current sample. We therefore applied an exploratory factor analysis to identify the underlying patterns in the responses to the complexity questions. Results from the principal component analysis with Varimax rotation (Eigenvalue >1, KMO 0.685, p 0.000) are shown in Table 2.

Four factors were identified, explaining 67% of the variance in complexity. Cronbach alpha values of 0.6 and higher indicate acceptable reliability for the first three factors [68]. The last factor was excluded from further analysis, as its Cronbach Alpha of 0.117 is far below the 0.6 threshold [68]. The three factors were expressed in terms of the variables identified in the rotated component matrix with a cut-off level of 0.5, as suggested by Hair et al. [68]. The grouping of variables was very similar to the original concepts of complexity of faith, fact and interaction, and therefore we kept the names of the complexity constructs.

		Complexity of Fact	Complexity of Interaction	Complexity of Faith	Other
C1	Maturity	-0.010	0.380	0.100	0.461
C2	Frequency of changes	0.083	-0.055	**0.901**	-0.027
C3	Severity of changes	0.176	0.054	**0.892**	0.048
C4	Uniqueness	-0.169	0.071	-0.109	**0.617**
C5	Information handling	**0.829**	-0.274	-0.078	-0.113
C6	Number of people involved	**0.876**	-0.018	0.137	-0.057
C7	Interdependencies	**0.889**	-0.023	0.039	-0.195
C8	Size	0.224	-0.301	-0.058	**0.678**
C9	Internationality	-0.174	0.128	0.303	**0.493**
C10	Interdisciplinary	**0.807**	0.109	0.222	0.171
C11	Transparency	-0.039	**0.843**	-0.116	0.107
C12	Empathy	-0.055	**0.876**	0.097	-0.058
	Cronbach Alpha	0.812	0.847	0.732	0.117
	Variance explained (%)	25.2	15.2	14.8	

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Table 2: Rotated component matrix for complexity factors

Complexity of fact was composed of C5, C6 and C7. Only C8, size, was dropped as it had a low factor loading. This is in line with the view of scholars like Maylor et al [85] on the difference between project size and project complexity. They argue that large projects are not necessarily complex. The present analysis confirms their argument, as size appears not to be relevant for differences in complexity. C10 (interdisciplinarity) was related to complexity of fact instead of interaction as qualitatively suggested. We decided to drop C10 from the complexity of fact construct, improving the Cronbach Alpha from .812 to .880. Complexity of faith was formed by C2 and C3. C1 (maturity) and C4 (uniqueness) had low factor loadings, and could not be considered as part of the same construct. Finally, complexity of interaction was formed by C11 and C12. The low importance of C09 (internationality) may be because the majority of the projects in the sample were executed within the same country.

We took the mean of the variables composing each construct as identified by the factor analysis. The variable on complexity of interaction was cubed so that it obeyed normality and homoscedasticity conditions.

3) Success

Operationalization of project success was done by using the model of Turner and Müller in [4] and [16], as explained above. The ten dimensions of success were assessed using five point Likert scales. The success measure reoccurring business was excluded due to reliability issues and a high amount of missing values (20%). Of the remaining 9 dimensions the mean was taken for the dependent variable project success. We cubed the variable to achieve acceptable normality. Cronbach Alpha was acceptable with .62 (Table 3).

The final measure extends the classic iron triangle, incorporating satisfaction of client and team. The measure for project specific success criteria allowed respondents to enter their own, project specific success criteria. Taken that no two projects are the same, this last criteria was important to give the respondent the flexibility to define what might impact this project in particular, contextualizing the measurement. Although some respondents did not differentiate between success criteria and success factors, and included factors related to the project organization, such as risk management and client engagement, the majority mentioned success criteria. Timely delivery, long-term impact and quality were the most mentioned criteria, which jointly stand for 44 percent of all mentioning.

4) Control Variables

In line with earlier studies (e.g. [69] and [70]) we used a control variable to reduce 'noise' in the hierarchical regression analyses. We chose Commitment of Followers as control variable, as it allowed for a summary level control of team satisfaction, understanding of the need for change, and team's commitment to the project and its organization. Follower commitment is measured through the LDQ. Further details of the measure can be found in [37].

Table 3 shows the scale descriptive of all variables, and Table 4 the product correlation matrix.

Measure	*N*	*Mean*	*Standard deviation*	*Original number of dimensions*	*Number of dimensions after factor analysis*	*Scale reliability (Alpha)*
Leadership competences						
IQ	117	39.28	3.03	3	3	0.790
MQ	117	39.97	2.80	5	5	0.860
EQ	117	39.99	2.45	7	5	0.760
Complexity						
Complexity of Fact	119	3.50	1.30	4	3	0.880
Complexity of Faith	117	3.15	0.96	4	2	0.847
Complexity of Interaction	119	5.52	0.95	4	2	0.732
Project success	119	107.01	21.84	10	9	0.620

Table 3: Scale descriptives

C. Results

A. Empirically validated measurement of complexity of projects

In the last decade, complexity has emerged as a concept to tailor approaches to the management of projects to their context, avoiding the traditional and highly criticized "one size fits all" approach. The work in complex projects made substantial progress in defining what constitutes complexity, that is, what are those aspects that make projects complex to manage. However, the models were still not empirically validated. The present work presents a measurement for complexity of projects which was successfully validated empirically. This is in itself an important contribution to the development of research in project complexity.

B. Moderating effect of complexity on the relationship between leadership and success

Respondents rated project success from a minimum of three (good) to a maximum of five (great) in all success criteria. This indicated that the respondents did not work on severely

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	Commitment	1																
2	IQ	.324**	1															
3	MQ	.334**	.724**	1														
4	EQ	.325**	.575**	.627**	1													
5	Complexity of Fact (1)	-.066	-.094	-.131	-.151	1												
6	Complexity of Faith (2)	-.221*	-.188*	-.138	-.033	.209*	1											
7	Complexity of Interaction (3)	.246**	.179	.236*	.285**	-.159	-.008	1										
8	IQ x Fact	.013	.113	.024	-.026	.976**	.189*	-.145	1									
9	IQ x Faith	-.134	.053	.042	.115	.210*	.968**	.038	.217*	1								
10	IQ x Interaction	.334**	.528**	.478**	.458**	-.195*	-.088	.927**	-.083	.045	1							
11	MQ x Fact	.007	.048	.060	-.025	.980**	.205*	-.142	.989**	.218*	-.104	1						
12	MQ x Faith	-.145	-.027	.093	.112	.202*	.971**	.042	.193*	.983**	.018	.219*	1					
13	MQ x Interaction	.324**	.406**	.554**	.458**	-.209*	-.062	.938**	-.120	.042	.963**	-.104	.065	1				
14	EQ x Fact	-.002	-.009	-.035	-.016	.989**	.233*	-.152	.985**	.233*	-.135	.989**	.225*	-.146	1			
15	EQ x Faith	-.163	-.088	-.023	.121	.209*	.985**	.034	.187*	.980**	-.015	.204*	.985**	.014	.233*	1		
16	EQ x Interaction	.311**	.315**	.389**	.501**	-.217*	-.030	.966**	-.147	.051	.950**	-.143	.056	.963**	-.149	.052	1	
17	Success	.209*	.141	.248**	.276**	-.207*	-.151	.293**	-.149	-.102	.357**	-.143	-.089	.382**	-.145	-.102	.385**	1

Table 4: Correlation matrix

failing projects, which increases the chances to identify patterns of practices of successful project management.. Samples dominated by failing projects would make it difficult to identify which practices relate to successful and which ones to unsuccessful project outcomes. The reduction in range, however, made the success measurement less granular, an effect that might influence the ability to find correct patterns or correlations in the sample when they are there. Comparisons of results with other related studies did not indicate that the present results were different and less credible. Taken together the positive effect that respondents worked on good projects and the negative effect that they used a smaller range balance each other.

Following Sharma et al in [40], we conducted a hierarchical regression analysis to test the moderating influence of complexity on the relationship between leadership profiles when improving the results of the project from 'good to great' (hypothesis H1). From the correlation matrix (Table 4) we can see a positive correlation between EQ, IQ and MQ and success, which is a prerequisite for testing hypothesis H1. In line with earlier studies (e.g. [67] and [70]) we addressed possible negative effects through multicollinearity by 'centering' the variables as in [71] – [73]. For that we calculated deviation scores from the mean for independent and moderator variables, and for the calculation of cross-products (e.g. dynamic *x* structural complexity).

The results are presented in Tables 6 to 8. VIF values under 2 showed no issues of multicolinearity among the independent variables. The control variable has no significant effect on project successes. EQ and MQ have a main effect on success (step 2), IQ has no effect. EQ has a slightly higher predictive power than MQ (R-square of 7.7% versus 5.9% respectively). This is supported through earlier studies reported in [4] and [6]. It is also supported by organizational and psychological studies, such as those by Goleman, Boyatzis and McKee [74] and the various studies done by Dulewicz and his colleagues (e.g. [15], [66], [67]).

The addition of the three complexity items in step 3 shows a significant main effect of Complexity of Interaction in all models. Adding the cross-products of elements of complexity in step 4 showed a moderating effect of Complexity of Faith on both the relationship between EQ and project success, as well as the relationship between MQ and project success. Complexity of Fact has a moderating effect on the relationship between MQ and project success. In all cases the presence of the moderating effect lowered the significance of the relationship between independent variable (EQ and MQ) and dependent variable (project success) to insignificance. The results suggest that Complexity of Interaction is not a moderator, but possibly an antecedent, intervening, suppressor or predictor, according to Sharma et al, [40]. However, Complexity of Faith and Complexity of Fact are pure moderators. Adding the complexities to the main affect of EQ and IQ on project success increases R-square to approximately 12%,

Variable entered	Dependent variable Overall success (N=114)			
	Step 1	**Step 2**	**Step 3**	**Step 4**
Commitment	.126	.043	-.019	.041
EQ		.261 **	.203 *	.093
Complexity of Fact (1)			-.111	3.409
Complexity of Faith (2)			-.131	-4.162 **
Complexity of Interaction (3)			.205 *	.387
EQ x 1				-3.507
EQ x 2				4.092 **
EQ x 3				-.210
F for regression	1.799	4.619 *	3.926 ***	3.678 ****
F for change	1.799	7.338 **	3.275 *	2.916 *
R-square	0.016	0.077	0.115	0.219

Main table contains standardized coefficient betas VIF < 2

* p ≤ 0.05

** p ≤ 0.01

*** p ≤ 0.005

**** p ≤ 0.001

Table 5: Hierarchical regression with EQ as independent, project success as dependent variable and complexity as moderator

Variable entered	Dependent variable Overall success (N=114)			
	Step 1	**Step 2**	**Step 3**	**Step 4**
Commitment	.126	.070	.007	.021
IQ		.152	.099	-.780
Complexity of Fact (1)			-.128	.797
Complexity of Faith (2)			-.108	-3.063 *
Complexity of Interaction (3)			.235 *	-.513
IQ x 1				-.914
IQ x 2				2.916 *
IQ x 3				.900
F for regression	1.799	2.07	3.148 *	2.884 **
F for change	1.799	2.230	3.763 *	2.261
R-square	.016	0.036	.127	0.180

Main table contains standardized coefficient betas VIF < 2

* p ≤ 0.05
** p ≤ 0.01
*** p ≤ 0.005
**** p ≤ 0.001

Table 6: Hierarchical regression with IQ as independent, project success as dependent variable and complexity as moderator

Variable entered	Dependent variable Overall success (N=114)			
	Step 1	**Step 2**	**Step 3**	**Step 4**
Commitment	.126	.032	-.026	.028
MQ		.261 **	.205 *	.850
Complexity of Fact (1)			-.120	3.656 *
Complexity of Faith (2)			-.108	-2.815 *
Complexity of Interaction (3)			.215 *	1.503
MQ x 1				-3.765 *
MQ x 2				2.687 *
MQ x 3				-1.519
F for regression	1.799	4.511 *	3.935 ***	3.694 ****
F for change	1.799	7.125 **	3.358 *	2.940 *
R-square	.016	0.059	.115	0.160

Main table contains standardized coefficient betas VIF < 2

* p ≤ 0.05
** p ≤ 0.01
*** p ≤ 0.005
**** p ≤ 0.001

Table 7: Hierarchical regression with MQ as independent, project success as dependent variable and complexity as moderator

C. Cross-industry comparison

We also explored the similarities and differences among types of projects involved in the sample: organizational change, IT and engineering projects. Although they may use different terminologies, face different problems and demand coordination of different sets of competences, the management of the projects still encountered similar types and intensities of complexities.

We used ANOVA to evaluate the variance between different project types. In order to conduct a reliable ANOVA test, the sample of each group must be at least greater than the number of dependent variables [68]. We have six dependent variables (IQ, EQ, MQ, Complexity of Faith, Fact, and Interaction,), therefore a minimum group sample of seven. Hair et al [68] also recommend a minimum cell size of 20 observations and equal or approximately equal sample sizes per group.

The majority of the projects in the sample were IT (N=44), organizational change (N=20) or a combination of both – IT enabled-change (N=29), making up approximately 77% of the sample. Although sole engineering and construction projects represent a small percentage of the sample (9%, N=10), the number of observations is just above the threshold and can be used for the ANOVA test. A limitation is that this group is still below the practical guide of 20 observations and groups do not have similar sizes [68]. Other combinations of engineering, IT and organizational change projects had very few observations, and were therefore eliminated for this analysis.

The results of Levene test were insignificant (p>.05), indicating no differences between the groups. ANOVA was also insignificant for all six variables, indicating that the variance in means of leadership and complexity is not significantly different in different sectors. The same test was undertaken for the dependent variable (success), and yield similar results. Due to low group size we also used the Mann-Whitney test to confirm the results. Mann-Whitney test is a non-parametric two-independent-sample test. The results confirmed the ANOVA test, showing the medians of EQ, IQ, MQ, Complexity of Faith, Fact and Interaction do not differ significantly across different types of projects.

V. Discussion

The implications of the above results include the need for a more diversified understanding of complexity types. An initial categorization of complexities into those with direct effects and those with indirect (or moderating) effects is indicated.

The former category (with direct effect) includes measures for the degree of transparency in information exchange and the empathy with stakeholders. This resembles partly dimensions from Goleman, Boyatzis and McKee'smodel of emotional intelligence (comprising self-awareness and self-management), and social intelligence (comprising social-awareness and relationship management) [74]. In this model transparency is one measurement dimension of self management as part of emotional intelligence and empathy is one measurement dimension of social awareness as part of social intelligence. The present study shows only a small, but significant, correlation between EQ measures and Complexity of Interaction. However, the standardized beta coefficients in Table 4 to 7 show similar orders of magnitude for Complexity of Interaction and those of EQ and MQ, thus indicating a potentially comparable importance as predictor variable for project success. This is also indicated by the strong increase of R-square as a result of the introduction of complexity variables in the regression model.

The latter category (with moderator effect) includes complexities that stem from traditional change management issues, like frequency and impact of changes to the project (i.e. Complexity of Faith, which moderates both EQ and MQ's relationship with success) and the amount of information to be processed, the number of people and organizations involved, as well the independence of technology, people and organizations (i.e. Complexity of Fact, which moderates MQ's relationship with project success). Change management issues appear to be more severe as they impact two of the hypothesized relationships, whereas amount and independence of information and people only show a moderating effect in the context of MQ leadership competences. The impact of MQ leadership competences on project success appears to be more vulnerable than EQ competences. Therefore EQ emerges as the more stable leadership competence for project managers in respect to impact on improving project success, which is also shown by [16] for project settings and, for example, by [36], [66], [67] and [74] for line organizations.

Comparing the measurements taken in the two complexity categories shows important differences in the nature of underlying metrics:

- communication content and interaction related measures have a direct effect, whereas
- merely quantitative measures in form of amounts, frequencies, magnitudes etc have moderator effects.

This indicates that the moderator effect category of complexities shape the context, to which a "fit" has to be achieved in order to maximize the impact of EQ and MQ on project success. This "fit" is accomplished by balancing the project managers EQ and IQ with the level of Complexity of Interaction, that is the communication content and interaction, in a way that EQ and MQ competences impact on success can be maximized when the need for empathy and information transparency is highest. Projects with high levels of Complexity of Interaction appear to provide the context for emotionally and managerially strong leaders to make best use of their competences to improve project results.

Higher levels of Complexity of Faith and Fact reduce the impact of EQ and MQ on project success. The more these complexities increase the more are other success factors than leadership competences needed to enhance project success.

IQ did not impact the improvement in project success, not even if moderated by complexity. However, IQ competencies are essential in decision making, it involves vision, critical analysis and judgment and understanding of the broader implications of decisions. It would have been expected that IQ would be helpful to cope with high Complexity of Fact and Faith, but this was not supported through the data. It is difficult to explain this without further qualitative information about the projects and the role of project managers. It implies that project managers are not playing a strategic role in projects, because competences in vision, judgment, broader understanding of impact of decisions do not seem to be relevant. This interpretation concur with what project managers report as self-defined success criteria, of which over 80% related to narrow-minded success criteria, such as iron-triangle, ways of organizing, and compliance with legislation and politics.

The magnitude of leadership competences and the perceived magnitude in complexities do not differ significantly across project types. This indicates that there is no "qualitative difference" between project managers of different disciplines. This does not preclude that there are "best fit" personality profiles for different types of projects, as shown by [4], [16] and [84]. The lack of differences in perceived project complexities across different types of projects indicates a difference in the nature of project complexities, but not in their magnitude, which supports the categorization of complexities used in this study.

VI. Conclusions

Within this study we investigated the effect of project complexity on the relationship between project managers' leadership competences and project success. For this we took a contingency theory perspective. A worldwide sample of 119 responses from project managers, collected through a web-based questionnaire, mainly from the IT industry and North American organizations was used. The moderating effect of project complexity was analyzed using hierarchical regression analysis.

We can now answer the research question. In line with our research hypothesis we found an impact of EQ and MQ on project success, but not so from IQ. We also observed a direct effect of Complexity of Interaction on project success. Two moderating effects were found:

a) the relationship between EQ and project success is moderated by Complexity of Faith

b) the relationship between MQ and project success is moderated by Complexity of Fact and Complexity of Faith.

The growing importance of leadership in increasingly complex roles and tasks was earlier shown for wider organizations, for example by Goleman [36] or Parry [38] and indirectly through different leadership styles for different types of projects by Turner and Müller [16]. The present study's results confirm this. Furthermore, the present study shows that the three types of complexity have different impact on project success. While Complexity of Fact and Faith moderate the EQ and MQ relationship with success, Complexity of Interaction with its main effect on project success could potentially be another independent or mediator variable, according to [40].

The theoretical implications of these results include that the impact of EQ and MQ on project success interacts with project complexity. This interaction is negative, which diminishes the impact of EQ and MQ on project success in case of increasing complexity. Increasing levels of Complexity of Faith and Fact in projects require therefore increasingly higher levels of EQ and MQ for them to remain impactful on project success. Which implies that leadership alone is not enough to cope with complexity.

Contrarily, projects with higher levels of Complexity of Interaction set the context for project managers to make best use of their EQ and MQ competences and influence project success directly.

The magnitude of EQ, IQ and MQ, as well as the perceived complexities do not differ across project types. This suggests that the communalities among challenges faced in different types of projects is larger than expected, suggesting potential for learning across sectors. The present study's types of complexity could be assessed in projects and used as a common language across types of projects, enabling us to better understand commonalities in project complexities.

Implications for management are:

- Increasing EQ and MQ skills impacts projects positively and directly. Emotional and managerial leadership skills training should be integrated into project manager training and development curricula.
- Each project should be carefully evaluated as to its specific structure of its complexities, the perceptions stakeholders have towards these complexities, and the leadership style needed to achieve the expected balance in hard and soft aspects of project success, given the specific structure of project complexities. Then a suitable project manager with the appropriate leadership skills should be appointed.

Projects with high levels of Complexity of Interaction should be staffed with project managers having highest levels of EQ and MQ, because there the project managers can develop to their full potential and influence project results to the largest extent through their leadership style.

The results raised new questions. Further studies on the perception of complexity at different levels of the organizational hierarchy or in different parts of the organizational network, or in different cultures or in different disciplines might enlighten other aspects of complexity in projects. The implications resulting from the coexistence of complexity and leadership competences in a project should be better understood through associated research studies. Studies on the leadership exercised by other members of the project team might clarify forms in which companies achieve the necessary combination of multi-level leadership for successful projects. For example, similarities between the semi-structure of Brown and Eisenhardt in [76] and the ambidextrous structures of O'Reilly III and Tushman in [77] applied to leadership competences. Another stream for further study is the relationship between complexity as a characteristic of projects and complexity as a characteristic of leaders. Complementary qualitative studies on the reasons underlying the necessity for different leadership profiles in different sectors would also aid the understanding of the relationship between complexity and leadership.

The study’s strengths are in the use of established concepts and measurement constructs to arrive at credible results, such as the competence school of leadership and the LDQ. The results fit well with related studies, which is another indicator for theoretical support of the study results. Limitations could be found in the relatively small sample size and the global nature of the study, which did not allow deriving at country or industry level results. This may be addressed in future studies.

The study’s impact on the understanding of leadership in projects of different types of complexity, and its link with project success cannot be overestimated, as this “new science of human relationship” [78] comes close to a *DNA of leadership*, which can migrate continually.

References

[1] K. Judgev, and R. Müller, “A Retrospective Look at Our Evolving Understanding of Project Success,” *Project Management Journal*, vol. 36, no. 4, pp. 19-31, 2005.

[2] KPMG, *Global IT Project Management Survey*, KPMG, USA, 2005.

[3] A. Shenhar, and D. Dvir, “Toward a typological theory of project management,” *Research Policy*, vol. 25, no. 4, pp. 607-632, 1996.

[4] R. Müller, and J. R. Turner, “Matching the project manager's leadership style to project type,” *International Journal of Project Management*, vol. 25, no. 1, pp. 21-32, 2007.

[5] E. Westerveld, “The Project Excellence Model: linking success criteria and critical success factors,” *International Journal of Project Management*, vol. 21, no. 6, pp. 411-418, 2003.

[6] D. Dvir, A. Sadeh, and A. Malach-Pines, “Projects and project managers: the relationship between project manager's personality, project, project types, and project success,” *Project Management Journal*, vol. 37, no. 5, pp. 36-48, 2006.

[7] J. R. Turner, and R. Müller, “The Project Manager's Leadership Style as a Success Factor on Projects: A Literature Review,” *Project Management Journal*, vol. 36, no. 2, pp. 49-61, 2005.

[8] A. Malach-Pines, D. Dvir, and A. Sadeh, “Project manager-project (PM-P) fit and project success,” *International Journal of Operations & Production Management*, vol. 29, no. 3, pp. 268-291, 2009.

[9] I. Briggs-Myers, *Introduction to Type*, Oxford: Psychologists Press, 1987.

[10] R. M. Belbin, *Management Teams*, London, UK: Heinemann, 1986.

[11] V. Dulewicz, and M. Higgs, “A new approach to assessing Leadership Dimensions, Styles & Context,” *Comptency & Emotional Intelligence Quarterly*, no. Winter, 2003.

[12] M. Higgs, “Is there a relationship between the Myers-Briggs type indicator and emotional intelligence?,” *Journal of Managerial Psychology*, vol. 16, no. 7, pp. 509-533, 2001.

[13] V. Dulewicz, and M. Higgs, “Assessing leadership styles and organisational context,” *Journal of Managerial Psychology*, vol. 20, no. 1, pp. 105-123, 2005.

[14] D. R. Gehring, “Applying traits theory of leadership to project management,” *Project Management Journal*, vol. 38, no. 1, pp. 44-54, 2007.

[15] L. Geoghegan, and V. Dulewicz, “Do Project Managers' Leadership Competencies Contribute to Project Success?,” *Project Management Journal*, vol. 39, no. 4, pp. 58-67, 2008.

[16] J. R. Turner, and R. Müller, *Choosing Appropriate Project Managers: Matching their leadership style to the type of project*, Newtown Square; USA: Project Management Institute, 2006.

[17] M. Gell-Mann, *Das Quark und der Jaguar: Vom Einfachen zum Komplexen. Die Suche nach einer neuen Erklärung der Welt*, Munich, Germany: Piper, 1996.

[18] J. L. Casti, *Complexification*, Cambridge; MA, USA: Abacus Press, 1994.

[19] A. Collins, and D. Baccarini, “Project Success - A Survey,” *Journal of Construction Research*, vol. 5, no. 2, pp. 211-231, 2004.

[20] R. Atkinson, “Project management: cost, time and quality, two best guesses and a phenomenon, it's time to accept other success criteria,” *International Journal of Project Management*, vol. 17, no. 6, pp. 337-343, 1999.

[21] S. Cicmil, and D. Hodgson, *Making projects critical*, Houndmills: Palgrave, 2006.

[22] T. Cooke-Davies, “The 'real' success factors on projects,” *International Journal of Project Management*, vol. 20, no. 3, pp. 185-190, 2002.

[23] C. Scott-Young, and D. Samson, "Team management for fast projects: an empirical study of process industries," *International Journal of Operations & Production Management*, vol. 29, no. 6, pp. 612-635, 2009.
[24] M. Engwall, "No project is an island: linking projects to history and context," *Research Policy,* vol. 32, no. 5, pp. 789-808, 2003.
[25] J. K. Pinto, and D. P. Slevin, "Project success: Definitions and measurement techniques," *Project Management Journal*, vol. 19, no. 1, pp. 67-73, 1988.
[26] T. Elkins, and R. T. Keller, "Leadership in research and development organizations: A literature review and conceptual framework," *The Leadership Quaterly*, vol. 14, pp. 587-606, 2003.
[27] W. Bennis, and B. Nanus, *Leaders: the strategies for taking charge*, New-York: Harper and Row, 1985.
[28] S. A. Kirkpatrick, and J. A. Locke, "Leadership: do traits matter?," *Academy of Management Executive,* vol. 5, no. 2, pp. 48-60, 1991.
[29] R. R. Blake, and S. J. Mouton, *The Managerial Grid*, Houston, TX: Gulf, 1978.
[30] R. Tannenbaum, and W. H. Schmidt, "How to Chose a Leadership Pattern," *Harvard Business Review,* vol. 36, no. 2, pp. 95-101, 1958.
[31] P. Hersey, and K. H. Blanchard, *Management of Organizational Behaviour*, Englewood Cliffs, NJ: Prentice Hall, 1988.
[32] R. J. House, "A Path-Goal Theory of Leadership Effectiveness," *Administrative Science Quarterly*, vol. 16, no. 3, pp. 321-328, 1971.
[33] G. Graen, and M. Uhl.Bien, "Relationship-based approach to leadership: Development of leader-member exchange (LMX) theory of leadership over 25 years: Applying a multi-level multi-domain perspective," *The Leadership Quarterly*, vol. 6, no. 2, pp. 219-247, 1995.
[34] B. M. Bass, *Handbook of Leadership: Theory, Research and Applications* New York: Free Press, 1990.
[35] A. Keegan, and D. N. Den Hartog, "Transformational leadership in a project-based environment: a comparative study of the leadership styles of project managers and line managers," *International Journal of Project Management*, vol. 22, no. 8, pp. 609-618, 2004.
[36] D. Goleman, *Emotional Intelligence*, New York, NY: Bantam Books, 1995.
[37] V. Dulewicz, and M. Higgs, "Assessing leadership styles and organisational context," *Journal of Managerial Psychology*, vol. 20, no. 1, pp. 105-123, 2005.
[38] K. Parry, "The seven sins and the seven virtues of leadership: which path to follow?," in Leading Matters Symposium, 2004.
[39] V. Dulewicz, and M. Higgs, "Emotional Intelligence: A Review and Evaluation Study " *Journal of Managerial Psychology*, vol. 15, no. 4, pp. 341-368, 2000.
[40] S. Sharma, R. Durand, and O. Gur-Arie, "Identification and Analysis of Moderator Variables," *Journal of Marketing Research*, vol. 18, no. August, pp. 291-300, 1981.
[41] G. J. Klir, *The Facets of System Science*, New York: Plenum Press, 1991.
[42] J. Yates, "Complexity and the limits to knowledge," *American Journal of Physiology-Regulatory, Integrative and Comparative Physiology*, vol. 27, no. 5, pp. 201-20, 1978.
[43] A. Jaafari, "Project management in the age of complexity and change," *Project Management Journal*, vol. 34, no. 4, pp. 47-57, 2003.
[44] H. Singh, and A. Singh, "Principles of Complexity and Chaos Theory in Project Execution: A New Approach to Management," *Cost Engineering*, vol. 44, no. 12, pp. 23-33, 2002.
[45] J. Thomas, and T. Mengel, "Preparing project managers to deal with complexity - Advanced project management education," *International Journal of Project*

Management vol. 26, no. 3, pp. 304-315, 2008.
[46] G. Patzak, *Systemtechnik - Planung komplexer innovativer Systeme: Grundlage, Methoden, Techniken*, Berlin, Germany: Springer-Verlag, 1982.
[47] W. R. Ashby, *An Introduction to Cybernetics*, 2nd ed., London, UK: Chapman & Hall Ltd, 1957.
[48] J. T. Luhman, and D. M. Boje, "What Is Complexity Science? A Possible Answer from Narrative Research," *Emergence*, vol. 3, no. 1, pp. 158-168, 2001.
[49] Simon.H, "The Architecture of Complexity," *Proceedings of the American Philosophical Society*, vol. 106, no. 6, pp. 467-482, 1962.
[50] F. Malik, *Strategie des Managements komplexer Systeme. Ein Beitrag zur Management-Kybernetik evolutionärer Systeme*, 7th ed., Bern, Switzerland: Haupt Verlag AG, 2002.
[51] R. Dawkins, *Der blinde Uhrmacher: Ein neues Plädoyer für den Darwinismus*, 2nd ed., Munich, Germany: Deutscher Taschenbuch-Verlag, 1996.
[52] J. A. Black, "Fermenting change - Capitalizing on the inherent change found in dynamic non-linear (or complex) systems," *Journal of Organizational Change Management* vol. 13, no. 6, pp. 520-525, 2000.
[53] F. Cramer, *Chaos und ordnung: Die komplexe struktur des lebendigen*, Stuttgart, Germany: Deutsche Verlags-Anstalt, 1988.
[54] P. Coveney, and R. Highfield, *Frontiers of complexity: The search for order in a chaotic world*, London: Faber and Faber Ltd, 1995.
[55] C. Perrow, *Complex organizations: a critical essay*, 2nd ed., New York: McGraw-Hill, 1979.
[56] J. H. Payne, "Management of multiple simultaneous projects: a state-of-the-art review," *International Journal of Project Management*, vol. 13, no. 3, pp. 163-168, 1995.
[57] D. Baccarini, "The concept of project complexity--a review," *international Journal of Project Management*, vol. 14, no. 4, pp. 201-204, 1996.
[58] T. Williams, *Modeling Complex Projects*, Chichester: Wiley & Sons Ltd, 2002.
[59] A. Shenhar, "One Size does Not Fit All Projects: Exploring Classical Contingeny Domains," *Management Science*, vol. 47, no. 3, pp. 394-414, 2001.
[60] L. Crawford, B. Hobbs, and J. R. Turner, *Project Categorization Systems*, Newton Square, PA, USA: PMI, 2005.
[61] J. Geraldi, "Patterns of Complexity: the Thermometer of Complexity," *Proceedings of 20th IPMA World Congress on Project Management*, pp. 495-502, 2006.
[62] J. Geraldi, and G. Adlbrecht, "On Faith, Fact, and Interaction in Projects," *Project Management Journal*, vol. 38, no. 1, pp. 32-43, 2007.
[63] P. M. Podsakoff, S. B. MacKenzie, J. Y. Lee *et al.*, "Common Method Biases in Behavioral Research: A Critical Review of the Literature and Recommended Remedies," *Journal of Applied Psychology*, vol. 88, no. 3, pp. 879-903, 2003.
[64] J. M. Conway, and C. E. Lance, "What Reviewers Should Expect from Authors Regarding Common Method Bias in Organizational Research," *International Journal of Business and Psychology*, vol. 2010, no. 25, pp. 235-334, 2010.
[65] V. Dulewicz, M. Higgs, and M. Slaski, "Measuring emotional intelligence: content, construct and criterion-related validity," *Journal of Managerial Psychology*, vol. 18, no. 5, pp. 405-420, 2003.
[66] J. Wren, and V. Dulewicz, "Leader Competencies, Activities and the Successful Change in the Royal Airforce," *Journal of Change Management*, vol. 5, no. 3, pp. 295-306, 2005.
[67] M. Young, and V. Dulewicz, "Leadership styles, change context and leader

performance in the Royal Navy," *Journal of Change Management,* vol. 6, no. 4, pp. 383-396, 2006.
[68] J. F. Hair, R. E. Anderson, R. L. Tatham *et al.*, *Multivariate Data Analysis*: Prentice Hall, USA, 1998.
[69] M. V. Tatikonda, and S. R. Rosenthal, "Successful execution of product development projects: Balancing firmness and flexibility in the innovation process," *Journal of Operations Management,* vol. 18, no. 4, pp. 401-425, 2000.
[70] Q. Zhu, and J. Sarkis, "Relationships between operational practices and performance among early adopters of green supply chain management practices in Chinese manufacturing enterprises," *Journal of Operations Management,* vol. 22, no. 3, pp. 265-289, 2004.
[71] L. J. Cronbach, "Statistical test for Moderator Variables: Flaws in Analysis Recently Proposed," *Psychlogical Bulletin,* vol. 102, no. 3, pp. 414-417, 1987.
[72] D. A. Hofmann, and M. B. Gavin, "Centering Decisions in Hierarchical Linear Models: Implications for Research in Organizations," *Journal of Management,* vol. 24, no. 5, pp. 623-641, 1998.
[73] J. Jaccard, C. K. Wan, and R. Turrisi, "The Detection and Interpretation of Interaction Effects Between Continuous Variables in Multiple Regression," *Multivariate Behavioral Research,* vol. 25, no. 4, pp. 467-478, 1990.
[74] D. Goleman, R. Boyatzis, and A. McKee, *Primal Leadership: Learning to Lead with Emotional Intelligence*, Boston, MA, USA: Harvard Business School Press, 2002.
[75] G. C. Green, "The impact of cognitive complexity on project leadership performance," *Information and Software Technology,* vol. 46, no. 3, pp. 165-172, 2004.
[76] S. Brown, and K. M. Eisenhardt, "The Art of Continuous Change: Linking Complexity Theory and Time-paced Evolution in Relentlessly Shifting Organizations," *Administrative Science Quarterly,* vol. 42, no. 1, pp. 1-34, 1997.
[77] C. A. O'Reilly, and M. L. Tushman, "The Ambidextrous Organization.," *Harvard Business Review,* vol. 82, no. 4, pp. 74-81, 2004.
[78] D. Goleman, *Social Intelligence: The New Science of Human Relationships,* London; UK: Hutchinson, 2006.
[79] P. Patanakul, D. Z. Milosevic, and T. R. Anderson, "A Decision Support Model for Project Manager Assignments," *IEEE Transactions on Engineering Management,* vol. 54, no. 3, pp. 548-564, 2007.
[80] R. Drazin, and A. H. van de Ven, "Alternative Forms of Fit in Contingency Theory," *Administrative Science Quarterly,* vol. 30, pp. 514-539, 1985.
[81] L. Donaldson, "Organizational Design and Life-Cycle of Products," *Journal of Management Studies,* vol. 22, no. 1, pp. 25-37, 1985.
[82] L. Donaldson, "Strategy and Structural Adjustment and Regain Fit to Performance: In Defence of Contingency Theory," *Journal of Management Studies,* vol. 24, no. 1, pp. 1-24, 1987.
[83] J. Thomas, and M. Mullaly, *Researching the Value of Project Management,* Newtown Square: Project Management Institute, 2008.
[84] R. Müller, and J. R. Turner, "Leadership competency profiles of successful project managers," *International Journal of Project Management,* vol. 28, no. 5, pp. 437-448, 2010.
[85] Maylor, H., Vidgen, R., & Carver, S. (2008). Managerial complexity in project-based operations: A ground model and its implications for practice. *Project Management Journal, 39*, 15-26.
[86] A. Shenhar, A. Tishler, D. Dvir *et al.*, "Refining the search for project success factors:

a multivariate, typological approach," *R&D Management*, vol. 32, no. 2, pp. 111-126, 2002.

[87] M. Hoegl, and H. G. Gemuenden, "Teamwork Quality and the Success of Innovative Projects: A Theoretical Concept and Empirical Evidence," *Organization Science*, vol. 12, no. 4, pp. 435-449, 2001.

[88] J. K. Pinto, and D. P. Slevin, "Project success: Definitions and measurement techniques," *Project Management Journal*, vol. 19, no. 1, pp. 67-73, 1988.

[89] T. Williams, "Assessing and moving from the dominant project management discourse in the light of project overruns," *IEEE Transactions on Engineering Management*, *52*(4), 497-508, 2005

Appendix 1: Models for project success measurement

Shenhar et al [86]	*Hoegl & Gemuenden [87]*	*Pinto & Slevin [88]*	*Collins and Baccarini [19]*	*Turner & Müller [16]*
Meeting operational performance	Team performance effectiveness	Time	Time	End-user satisfaction
Meeting technical performance	Team performance efficiency	Budget	Cost	Supplier satisfaction
Meeting project schedule	Personal success in work satisfaction	Project performance	Quality	Team satisfaction
Staying within budget	Personal success in learning	Client satisfaction	Meeting project owners' needs	Other stakeholders' satisfaction
Addressing a recognized need		Technical validity		Performance in terms of time, cost, quality
Solving a serious problem		Organizational validity		Meeting user requirements
Product used by customer		Organizational effectiveness		Project achieves its purpose
Customer satisfaction				Customer satisfaction
Achievement of commercial success				Projects self defined success criteria
Increased market share				
Created new market				
Created new product line				
Developed a new technology				

Appendix 2: IQ, MQ and EQ dimensions

This appendix contains a brief description of the 15 competency dimensions of Dulewicz and Higgs (2005).

A. Intellectual Dimensions

1. Critical Analysis and Judgment

Gathering relevant information from a wide range of sources, probing the facts, identifying advantages and disadvantages. Sound judgements and decisions making, awareness of the impact of any assumptions made.

2. Vision and Imagination

Imaginative and innovative. Having a clear vision of the future and foresee the impact of changes on implementation issues and business realities.

3. Strategic Perspective

Sees the wider issues and broader implications. Balances short and long-term considerations and identifies opportunities and threats.

B. Managerial Dimensions

4. Resource Management

Organizes resources and co-ordinates them efficiently and effectively. Establishes clear objectives. Converts long term goals into action plans.

5. Engaging Communication

Engages others and wins their support through communication tailored for each audience. Is approachable and accessible.

6. Empowering

Gives direct reports autonomy and encourages them to take on challenges, to solve problems and develop their own accountability.

7. Developing

Encourages others to take on ever more-demanding tasks, roles and accountabilities. Develops others' competencies and invests time and effort in coaching them.

8. Achieving

Shows an unwavering determination to achieve objectives and implement decisions.

C. Emotional Dimensions

9. Self-awareness

Aware of one's own feelings and able to recognize and control them.

10. Emotional Resilience

Capability for consistent performance in a range of situations. Retain focus on a course of action or need for results in the face of personal challenge or criticism.

11. Intuitiveness

Arrive at clear decisions and drive their implementation in the face of incomplete or ambiguous information by using both rational and 'emotional' perceptions.

12. Interpersonal Sensitivity

Be aware of, and take account of, the needs and perceptions of others in arriving at decisions and proposing solutions to problems and challenges.

13. Influence

Capability to persuade others to change a viewpoint based on the understanding of their position and the recognition of the need to listen to this perspective and provide a rationale for change.

14. Motivation

Drive and energy to achieve clear results and make an impact.

15. Conscientiousness

Capability to display clear commitment to a course of action in the face of challenge and to match 'words and deeds' in encouraging others to support the chosen direction.

Appendix 3: Theoretical framework for complexity

Type of Complexity	Project Management				General
	Geraldi (2006)	Crawford et al (2005)	Turner & Müller (2006)	Others	
Complexity of Faith	Dynamic			Pace (Dvir et al. 2006)	Dynamism (Kallinikos, 1998, Patzak, 1982)
	Immaturity		Clarity of goals		Lack of clarity (Reither, 1997)
			Level of ambiguity/uncertainty	Uncertainty (Williams, 2002)	
	Impact of Changes				
				Difficulty (Frame, 2002)	
			Risk source and location		
	Uniqueness & Customisation			Technological Uniqueness (Shenhar and Dvir, 1996) i.e Novelty (Dvir et al. 2006)	
					Uniqueness (Klir, 1991)
			Familiarity		
Complexity of Fact	Size	Size of the project			
	Number of Sources	Number of departments involved	Number of functions or skills;		Large number of elements (Patzak, 1982) or variables (Ashby, 1957)
		Number and type of stakeholders			
			Technical complexity	Scope (Shenhar and Dvir, 1996)	
			Number of sites, locations, countries		
			Project scope		
		Form of contract			
	Quantity of Information				
	Tech. and Commercial Interdependence				Variety of relationships (Ashby, 1957, Klir, 1991, Simon, 1982, etc)
Complexity of Interaction	Transparency				
	Empathy				