

A process framework for theoretically grounded prescriptive research in the project management field

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Abstract

Prescriptive research is at the heart of the project management (PM) disciplines. For decades, researchers and practitioners alike have been searching for methodological solutions to practical project management problems. Scheduling methods or risk management methodologies are just two examples. Despite this long tradition of prescriptive research, PM methods suffer from a number of problems, such as a lack of acceptance in practice, limited effectiveness, and unclear application scenarios. In this article, we identify a lack of empirical and theoretical foundations as one cause of these deficiencies. Based on a review of existing PM literature and a thorough analysis of other successful prescriptive disciplines, we develop a framework designed to serve as a guideline for theoretically grounded prescriptive PM research. The framework outlines how theories and empirical investigations can help build applicable and useful prescriptive research results. We illustrate our framework by applying it to the case of the critical chain method. Our contribution is twofold: our research results can foster the discourse on methodological support for prescriptive PM research; it may also help set up viable prescriptive research designs.

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1. Introduction

Methods for successfully initiating, planning, executing, and closing projects are at the heart of the project management (PM) discipline. Scheduling algorithms or risk management methodologies are just some prominent examples of such management methods, which constitute the notion of PM as an action-oriented² discipline that helps people and organizations solve practical problems in the context of projects (Shenhar and Dvir, 2007). The development of such methods is a major concern of project management practice and research alike,

which is why one would have expected PM to have reached a high level of expertise and maturity in delivering methods to solve practical project problems. Surprisingly, the opposite seems to be the case: Numerous studies report on serious problems related to proposed PM methods. The problems are diverse; they include:

- The usefulness and effectiveness of PM methods cannot be proven (Crawford, 2005; Thomas and Mullaly, 2007).
- There is a lack of universal applicability as well as a lack of consideration of the usage environment (contextual factors) and antecedents of successful application of methods (Besner and Hobbs, 2006; Morris et al., 2006; Russo et al., 1996).
- PM methods suffer from low adoption and individual acceptance rates (Ahlemann et al., 2009).

These problems are a major challenge for practitioners, who are interested in useful approaches to master project management; it seems as if no simple remedy is available, as too little is known about when, why, and how PM methods actually work.

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² In this context, action-orientation does not refer to the “action research” paradigm. An action-oriented discipline aims to develop solutions for real world problems.

In many cases, we lack an empirical foundation and deeper theoretical understanding of PM methods beyond their mere application (Packendorff, 1995; Williams, 2005). Theories can help us ground the design of PM methods on existing knowledge with a high degree of validity, and an empirical foundation could lead to better PM methods that provide an idea of the extent of and conditions for their effective use. Even more, we believe that a theoretically and empirically sound foundation and testing of PM methods are indispensable if PM is to gain legitimacy and credibility as a branch of science with a cumulative research tradition and a solid body of theoretical knowledge (Cicmil and Hodgson, 2006; Packendorff, 1995; Smyth and Morris, 2007; Whitty and Maylor, 2009). In the following, we use the term prescriptive research to denote this action-oriented form of science, which is concerned with the development of recommendations on how to solve practical problems (“how”). In contrast, theoretical research often tries to describe reality (“what”) and seeks to explain and predict phenomena (“why”) (Gregor and Jones, 2007; Hevner et al., 2004). Prescriptive research results mostly require adaptation prior to their use in order to account for contingencies in the usage environment. Furthermore, practitioners have to ensure that the organization is willing to adopt the research results (Davies and Kochhar, 2000; O’Dell and Grayson, 1998) by taking the required measures.

Prescriptive research can, but does not have to, draw on a particular epistemological stance. Recommendations on how problems can be solved can either be the result of an interpretive research process, or a positivist approach. For example, the former may materialize in a research process with experts exchanging their experience and finally agreeing on the problem solution, while the latter may form the basis for experimental research designs. Although the two processes differ in terms of their philosophical underpinnings, they are both forms of prescriptive research. While this paper focuses solely on prescriptive research, we regard theory building as equally important; furthermore, it has a particular relevance in respect of prescriptive research by providing the foundation.

In this article, we will first review the scientific PM literature and analyze its state regarding theoretical and prescriptive research results. This will help us deepen our understanding of the extent to which the design of PM methods is theoretically and empirically grounded as well as what challenges current researchers face when conducting prescriptive research. We will then describe how other prescriptive research disciplines approach method development and method testing. Due to their high maturity, we concentrate on evidence-based practices and design science research and investigate how they construct viable solutions to real-world problems. Based on these findings, we will then derive a process framework for prescriptive PM research that explains how theoretical and empirical insights can form a basis for the design of PM methods. To demonstrate the framework’s use, we apply it to the case of the critical chain method, which is a rare example of sound method development and evaluation in the PM discipline. The last section summarizes the findings, draws final conclusions, discusses our study’s limitations, and presents future research opportunities.

2. Project management as action-oriented discipline

A literature analysis offers the potential to (a) summarize the current state of research, (b) identify relationships, contradictions, gaps, and inconsistencies, and (c) suggest next steps to solve or address problems prevalent in this research domain (American Psychological Association, 2001). Our literature review was conducted to answer three questions pivotal to the article’s research objective:

1. *What is the project-related body of knowledge that can serve as a foundation for prescriptive PM research?* Theories can form the basis for PM methods and can help us understand why and under which conditions they yield the intended results. A lack of theories developed by PM research may render it necessary to develop new PM-specific theories or to borrow theories from neighboring disciplines.
2. *What types of solutions are constructed for project-related problems?* The answer to this question helps us understand the nature of problem solutions developed as a result of prescriptive PM research which, in turn, allows us to shape the research framework accordingly.
3. *What are the methods used to develop the solutions for project-related problems?* We aim to assess the state of solution development methodologies in PM research to identify the PM discipline’s needs in this area. Actual solution development methods can also form the foundation for our framework.
4. *What evaluation approaches have proven useful with regard to method design and testing?* Not all evaluation approaches may be of help concerning the testing of PM methods. The framework must integrate the successful approaches and must prioritize them, as each evaluation approach generates different kinds of insights.

Due to the focus of these perspectives, we chose a concept-centric approach to the literature review, as proposed by (Webster and Watson, 2002), and performed three subsequent steps to arrive at our conclusions: (1) source, time, and paper selection, (2) review and classification, and (3) analysis. These steps are discussed in the following.

2.1. Source, time, and paper selection

Because it was our intention to get a good cross-sectional overview of the research that the PM discipline is conducting, we decided to focus on a leading PM journal: the *International Journal of Project Management* (JPMA). We aim to investigate the actual state of PM (prescriptive) research. Hence, we restricted our analysis to the past 5 years (2006 to October 2010), as this timeframe should be suitable to provide a good snapshot of contemporary project management research and to focus on the most recent methodological and theoretical advances. This study is not focused on investigating the development of PM prescriptive research over the time. Instead, we intend to collect a representative sample that will capture the current state of PM research.

2.2. Review and classification

The papers' review and classification were done by two researchers, to strengthen inter-coder reliability. Since we aim to discover how PM solutions are developed and evaluated, we grouped all papers proposing solutions to concrete PM problems in the *prescriptive* category (McElroy, 1982). The other categories were built by investigating the types of research questions that the papers attempt to answer and the resulting contribution types. We then refined our categories in a second step using definitions from the literature. The prescriptive papers were further analyzed in terms of their theoretical foundation (if any), the methods used for solution development (if mentioned), and the type of result evaluation (if performed). We gathered all theories that were employed for solution design and evaluation. Divergent classifications were subject to a reconciliation phase. The analysis was done applying the qualitative data analysis software Atlas.ti 6. In total, 422 papers were analyzed (Table 1a). The majority of the inspected papers were descriptive (216 papers, 51.18%). We found that only 10 papers of the 422 papers (2.37%) dealt with theories in the PM field. 120 papers could be classified as prescriptive (28.43%), of which only 23 papers have a solid theoretical foundation (Table 1c). Only 62 prescriptive papers reported on research result evaluation, by applying one or more evaluation methods.

2.3. The project-related body of knowledge

Our review of the JPMa papers confirms that theoretical work in PM research is underdeveloped, as noted by many prominent authors (Cicmil and Hodgson, 2006; Jugdev, 2004; Koskela and Howell, 2008; Smyth and Morris, 2007; Söderlund, 2004; Turner, 1999). This may be due to two reasons: First, the discipline's maturity can still be characterized as low. Although PM practices have been known for centuries, PM research is still in its infancy compared to the natural sciences, for example. PM still does not have a coherent and comprehensive theoretical body of knowledge (Jugdev, 2004). Second, PM is multidisciplinary and, as a result, draws on theories from various neighboring disciplines (Table 1c), such as engineering, social sciences, psychology, or operations research (Kwak and Anbari, 2009).

The lack of PM-specific theories has the following consequences for prescriptive PM research: (1) Given the PM discipline's current theoretical state, researchers should consider theories from neighbor disciplines to ground their prescriptive research. (2) Given the popularity of prescriptive research in the

PM community (2nd most prominent paradigm), it is promising to use the prescriptive research process to gain theoretical insights that can be useful for building PM theories.

2.4. Types of prescriptive research results

Prescriptive research plays an important role. Prescriptive papers are the second most important paper type. We noted 10 times more prescriptive papers than theory-building papers. Among the solutions produced by prescriptive research, procedural recommendations—in the sense of methods—clearly dominate the field (Table 1b). This is unsurprising, considering that PM practice is characterized by the idea that solving project-related problems can be achieved by approaching them in a structured and replicable way, step by step. The second most important prescriptive research results are models and frameworks that provide a (simplified) picture of reality. Mostly, they describe the structure of a problem solution, serving as a template for practitioners. It is worthwhile mentioning that the literature discusses these two prescriptive research results on very different levels of detail: Sometimes, the results only consist of a set of guiding principles (very abstract), while they are precisely formulated at other times, making them easy to implement or even to simulate. In the following, we consider all forms of solutions whether very detailed or very abstract. Besides these two general types (which account for more than 97% of the papers analyzed), there are software-related artifacts (e.g., software ontologies, references models for software components) or entire systems. Therefore, we can conclude: There are three major prescriptive result classes in PM-related research, namely (1) processes for solving a problem, (2) architectural templates for problem solutions, and (3) artifacts facilitating software design. Since not all PM problems can be solved through the use of a computer program (e.g., organizational problems) and due to the abundance of literature available on the grounded design of software (e.g., Henderson-Sellers and Edwards, 1990; Nuseibeh and Easterbrook, 2000; Thomas, 2006), we conclude that prescriptive research guidelines should principally focus on procedural approaches (i.e. methods) and architectural blueprints (i.e. models and frameworks) of problem solutions.

2.5. Methods used to develop prescriptive research results

Our analysis shows that 32 of the 120 prescriptive papers (26.66%) do not deliver information about the solution development process (See Table 1d). This reflects a relative nonchalance

Table 1a
Paper type.

<i>Descriptive</i>	Descriptive research is research answering the questions regarding <i>what</i> and <i>how</i> as well as <i>Yes/No</i> questions (Knapfer and McLellan, 1996)	216 (51.18%)
<i>Prescriptive</i>	Prescriptive research seeks to help people solve practical problems by developing and testing artifacts (McElroy, 1982)	120 (28.43%)
<i>Other</i>	Literature analysis, editorials, reports, book reviews, and calls for papers/abstracts/participation	39 (9.24%)
<i>Conceptual</i>	Conceptual papers present assumptions, premises, axioms, assertions, etc. without empirical work (Hirschheim, 2008)	37 (8.76%)
<i>Theory</i>	A theory should fulfill three criteria: (1) a theory must have clear constructs; (2) the relationships between the constructs must be defined; and (3) a theory must be testable (Doty and Glick, 1994). It should also provide explanations and predictions (Kerlinger, 1973)	10 (2.37%)
Σ		422 (100%)

Table 1b
Prescriptive papers: research result type.

<i>Method</i>	A method is “a set of steps (an algorithm or guideline) used to perform a task” (March and Smith, 1995)	57 (47.5%)
<i>Model</i>	A model is “a set of propositions or statements expressing relationships among constructs” and “can be viewed simply as a description, that is, as a representation of how things are” (March and Smith, 1995)	42 (35%)
<i>Framework</i>	A framework is a frame, a supporting system, a meta-architecture of a system (Grigoriu, 2006)	18 (15%)
<i>Ontology</i>	Ontology is a special kind of information object that aims to formally model the semantic concepts of a domain (Guarino et al., 2009)	1 (0.83%)
<i>Reference model</i>	A reference model is an “information model used for supporting the construction of other models” (Thomas, 2006)	1 (0.83%)
<i>System</i>	A system is “a set of interrelated components working toward a common objective” (Carlsson et al., 2002)	1 (0.83%)
Σ		120 (100%)

on the part of the PM researchers regarding methodological matters in prescriptive research. This is problematic, as it is difficult to assess a solution’s quality without details about its development phase. The lack of consideration of methodological issues in solution development is not specific to the PM discipline, but seems to hold for other management disciplines as well. For example, solution development was not discussed in the well-known series—edited by Ketchen and Bergh (2004, 2005, 2006, 2007, 2009, 2011)—dealing with research methodology in strategy and management.

The remaining 88 prescriptive papers use one or many solution development methods. We found that literature analysis (Webster and Watson, 2002) is the most frequently used method in solution development (54 papers; 45%). The authors review theories and relate (prescriptive) work to build a new solution for a PM problem. 28 papers (23.33% of all prescriptive papers) use mathematical and logical deduction. These papers generally deal with optimization (e.g., schedule optimization) and risk evaluation problems. The problem is translated into mathematical formalisms, which form the basis for an in-depth logical or mathematical analysis. A PM solution design framework should thus afford researchers the freedom and opportunity to approach

PM problems with mathematical formalisms, as well as qualitative, textual descriptions.

In 25 papers (20.83%), empirical data is collected and analyzed (Bryman and Cramer, 1990; Miles and Huberman, 1984) to gain insights into the PM problem to be solved and to guide the solution development process. This allows a better understanding of the problem and the development of solutions that fit concrete problem patterns revealed by the empirical data analysis. Difficult theoretical inspection of PM problems due to the lack of a wide PM theoretical body of knowledge can also explain this use of empirical data in solution development.

2.6. Evaluation approaches

As our analysis shows, little is done to assure that prescriptive research results really apply and yield the intended benefits (Table 1e). Grounding prescriptive research with theoretical knowledge and rigorously seeking for empirical evidence that proves problem solutions’ effectiveness are not widespread practices in PM research. Among the few papers that evaluate their solutions, case studies (single and multiple, (Yin, 2009)) are the most prominent approach (24 papers, 20%). Researchers tend to opt for case-based evaluations, because it seems natural: a new problem solution is applied in a real-world setting, and the research observes the results. Also, case studies have the potential to make complex social interactions and phenomena transparent. But case studies also have downsides. Besides the fact that it is not always easy to find an organizational environment in which to test the solution, case studies require in-depth data collection and analysis work. This may be the reason why most researchers concentrate on only one case, which limits these findings’ generalizability.

The second most important evaluation approach is simulation (Pidd, 1998) (19 papers, 15.83%)—testing the solution in a controlled environment, mostly based on either fictitious or historical data. Simulations’ advantages include cost efficiency

Table 1c
Prescriptive papers: theoretical foundation.

<i>Number of prescriptive papers</i>	120 (100%)
<i>No foundation: No theory is used in the artifact development process to justify the design decisions</i>	97 (80.83%)
<i>Fuzzy set theory</i>	5 (4.16%)
<i>Organization theory</i>	2 (1.66%)
<i>Theory of constraints</i>	2 (1.66%)
<i>Arbitrage pricing theory</i>	1 (0.83%)
<i>Theory of social constructivism</i>	1 (0.83%)
<i>Contingency theory</i>	1 (0.83%)
<i>Evidence theory</i>	1 (0.83%)
<i>Game theory</i>	1 (0.83%)
<i>Graph theory</i>	1 (0.83%)
<i>Lifecycle management theory</i>	1 (0.83%)
<i>Management control theory</i>	1 (0.83%)
<i>Negotiation analysis approach</i>	1 (0.83%)
<i>Organizational psychology theory of job performance</i>	1 (0.83%)
<i>Porter's generic strategies</i>	1 (0.83%)
<i>Pragmatic theory of knowledge</i>	1 (0.83%)
<i>Stakeholder theory</i>	1 (0.83%)
<i>Theory of convention</i>	1 (0.83%)

Table 1d
Prescriptive papers: methods used for solution development.

<i>Number of prescriptive papers</i>	120 (100%)
<i>No details: the paper provides no details on the solution development process</i>	32 (26.66%)
<i>Literature analysis</i>	54 (45.00%)
<i>Mathematical and logical deduction</i>	28 (23.33%)
<i>Empirical data analysis</i>	25 (20.83%)

Table 1e
Prescriptive papers: evaluation.

<i>Number of prescriptive papers</i>	120 (100%)
<i>No evaluation: no evaluation method is used in the paper to assess the effectiveness of the proposed artifact</i>	58 (48.33%)
<i>Case study (single or multiple)</i>	24 (20.00%)
<i>Simulation</i>	19 (15.83%)
<i>Survey</i>	10 (8.33%)
<i>Expert opinion</i>	9 (7.5%)
<i>Meta-analysis</i>	3 (2.5%)
<i>Literature review</i>	2 (1.66%)
<i>Text analysis</i>	1 (0.83%)

(compared to case research) and ease of repeatability (Pidd, 1998). However, due to testing environment limitations, they may not detect problems of adoption and forego the success that results from more complex social interactions that take place in real-world settings. Simulations may be a suitable approach at an early stage of solution development.

To sum up, many prescriptive research endeavors are immature in terms of their theoretical foundation and the application of a proper research methodology. Very often, researchers seem to concentrate solely on the outcome of their work (i.e. the solution to a PM problem) instead of investing time in theoretical and methodological considerations. We also found no evidence that the PM research discipline is working on anything resembling a meta-theoretical basis for prescriptive research that addresses questions such as how to organize prescriptive research or how to evaluate prescriptive research methods. It is therefore prudent to look beyond project management research to other disciplines that have successfully derived rigorously evaluated practical advice from sound theoretical foundations.

3. Method development in other action-oriented disciplines

There are many research disciplines (e.g., medicine, engineering, information systems research) that are comparable in their prescriptive nature to project management. They all share the production of artifacts to solve practical problems. We will therefore look at two major artifact development and testing paradigms that have seen successful use in several other research areas: First, we consider the design science approach, as it is employed by many engineering specializations, in educational science, political science, and information systems research. For the purpose of this article, we refer to the design science concept coined by Simon (1996), who defines it as the scientific study of the artificial, as opposed to the notion by Gregory (1966), who states that the process of design can never be scientific. The research stream going back to Simon acknowledges that, as solutions to people's problems, artifacts can indeed be designed in a scientific research process.

Second, we will look at the evidence-based approach to professional practice, as it is increasingly used in medicine and the management disciplines. It can be seen as complementary to design science, since it departs from a given set of possible problem solutions and is primarily concerned with selecting appropriate solutions and proving their effectiveness (Sackett and

Rosenberg, 1995). Both approaches are summarized and compared in Table 2.

3.1. Design science

The design science paradigm has been developed as a technology-oriented counterpart to natural sciences (Gregor and Jones, 2007; March and Smith, 1995; Simon, 1996). Its purpose is the design of artifacts that serve human beings. Artifacts can either be tangible (e.g., buildings, machines) or intangible (e.g., methods, recipes, software). Project management methods can be regarded as artifacts that have been designed to assist project managers during their work. For example, they help to solve time planning or resource leveling problems. The design science paradigm is mainly concerned with the question how to design viable and useful artifacts and there is broad consensus that both construction and evaluation techniques are required for this purpose. While scholars have constantly emphasized the importance of rigorous research activities as part of the overall design process and have proposed numerous methods for this purpose (e.g., case research, field research, controlled experiments, and simulations) (Hevner et al., 2004), the initial guidelines on good design practices were very abstract. This has changed considerably over the years; at present, researchers can draw on a number of approved procedures for problem solution design and testing. For example, Van Aken (2004) proposes case-based alpha and beta testing—the former allowing for the application of the solution in its original context, and the latter for a solution's careful translation to new, extended contexts. Scholars have also made progress in adapting established methods to the specific needs of design research; much like Sein et al. (2011) did with the action research method. In the design research discipline, there is ongoing discourse on the question as to how artifacts can be documented, as scholars are experiencing two major challenges in this regard: First, the artifact itself is often uninteresting, because it solves a specific problem related to a very specific context. For this reason, it is often useful to search for a more abstract solution description that can serve as a solution to a class of problems, i.e. to a class of (slightly) different contexts (Gregor and Jones, 2007). Second, an artifact's usefulness for practice and science is very limited when it is presented in its bare form, without any additional (and formalized) information about, for example, its purpose, scope, and/or intended outcomes (Gregor and Jones, 2007). This information is necessary for an artifact's proper application and use for future, cumulative research. In an attempt to address this problem, several researchers have made suggestions and have proposed frameworks for structuring and presenting the results of prescriptive design-oriented research. The most influential proposal was made in the 1990s by Walls et al. (1992), who defined a framework for specifying solutions to a class of problems, explicitly considering a process of tailoring the artifact to specific contexts. They called this framework 'design theory' because it also included theoretical underpinnings of the artifact ('kernel theories') and propositions reflecting how the artifact works. Walls et al. (1992) was later refined by Gregor and Jones (2007),

Table 2
Overview of design science and evidence-based practice.

	Design science	Evidence-based practice
Purpose	Design of artifacts that serve human beings (tangible and intangible)	Improve the effectiveness of professional practice
Scope	Approaches for constructing and evaluating artifacts	Rigorously research the effectiveness of professional procedures and make this knowledge available to practitioners
Fields of application	• Architecture (Hillier et al., 1972; Maver, 1970) • Engineering (Hubka and Eder, 1987; Roozenburg and Eekels, 1995) • Urban planning (Schön, 1983) • Information systems (Gregor and Jones, 2007; Hevner et al., 2004; March and Smith, 1995; Walls et al., 1992) • Educational sciences (Cobb et al., 2003; Wittmann, 1995) • Political science (Bobrow and Dryzek, 1987; Linder and Peters, 1984)	• Medicine • Education (Slavin, 2002) • Social work (Webb, 2001) • Librarianship (Eldredge, 2006) • Organization studies (Denyer et al., 2008) • Management (Pfeffer and Sutton, 2006)
Fundamental tenets	• Depart from an important practical problem to assure relevance (Hevner et al., 2004) • Follow established research methods to construct and evaluate a solution to assure rigor (Hevner et al., 2004) • Make a clear contribution to the scientific/theoretical body of knowledge (Gregor and Jones, 2007) • Inform the artifact's design by the existing theoretical body of knowledge (Gregor and Jones, 2007) • Have a cyclical search process comprised of a design artifact's continuous adjustment, refinement, and evaluation (Van Aken, 1994)	• Apply randomized controlled trials to judge a medical procedure's effectiveness (Sackett and Rosenberg, 1995) • Practitioners place their trust in research-backed courses of action (Hsu et al., 2008) • Researchers have the responsibility to address any doubts concerning the research quality (Hsu et al., 2008) • Procedures need to be well-documented and research results must be easily retrievable (Haynes and Haines, 1998) • Adapt medical education so that practitioners are enabled to interpret research findings (Evidence-Based Medicine Working Group et al., 1992)

who propose an advanced specification of a design theory’s constituent elements, including scope and artifact mutability.

The design science paradigm offers a number of lessons that are relevant to prescriptive PM research:

1. *Theoretical grounding of artifacts*: Theories can inform artifact design by providing explanations as to how and why an artifact yields a certain desired outcome, thus enhancing an artifact’s ‘validity.’
2. *Testable artifacts*: Artifacts need to be testable in terms of viability and performance by seeking the best artifact for a particular class of problems. To allow for such examinations, testable propositions are required.
3. *Design as a cyclical research process*: Artifact development involves cyclical construction and evaluation activities that end when the artifact can no longer be improved and/or is better than existing artifacts. During this process, the researcher considers alternative designs and refines existing designs.
4. *Methodological pluralism*: Researchers can draw on a multitude of different methods for their artifact design and evaluation. Each method has its particular advantages and disadvantages in terms of the insights it can potentially generate. For this reason, it is advisable to follow a multi-method approach that applies different contexts.
5. *Artifact mutability and instantiation*: Only in very rare cases are artifacts usable ‘out of the box.’ Due to changing contextual conditions of their use, artifacts require an instantiation, which includes extension or modification. This forces the design researcher to think about how an artifact can be adapted to specific situations.

3.2. Evidence-based practice

Evidence-based practice has its roots in medicine and is increasingly also finding favor and application in other disciplines

(See Table 2). Practicing medicine is in some ways similar to managing projects. Like project managers, medical practitioners are often forced to make quick decisions with serious consequences. And like project managers, physicians have long relied on a mixture of intuition, personal experience, anecdotal evidence, and deductive reasoning. As a result, doctors often prescribed treatments that were either ineffective or less effective than known alternatives. Evidence-based medicine (EBM) is a multifaceted approach to address these problems by promoting the use of current research findings in medical practice (Evidence-Based Medicine Working Group et al., 1992).

Practitioners in the field employing an evidence-based approach are asked to give up some of their autonomy and to place their trust in research-backed courses of action, even if they run counter to intuition or conventional wisdom (Hsu et al., 2008). It is therefore researchers’ responsibility to address any doubts concerning research quality and to build credibility for the scientific process. Besides the quality of research, its ease of application is essential. The results must be easily retrievable and comprehensible in the course of practitioners’ daily routine. Thus, medical research is now increasingly made available through specialized databases (e.g., the Cochrane library) that offer concise, quickly understandable summaries.

A thorough analysis of the experiences of evidence-based medicine and evidence-based approaches in other disciplines reveals some starting points for the furthering of prescriptive project management research:

1. *Empirical evidence*: Before solutions to practical problems are recommended and applied, they require empirical evidence that proves their effectiveness. Both positive and negative empirical results are of interest and should be published. Studies designed to deliver empirical evidence must be conducted rigorously.
2. *Methodological standards*: Evidence-based research suggests that a generally accepted standard of evaluation is advisable.

This has a twofold advantage: First, researchers obtain clear guidelines for their research. Second, other researchers and practitioners can better judge the research's quality.

3. *Documentation standards*: Clear standards for documenting research results make it easy for the scientific community to judge their colleagues' work. They will also facilitate the comparison of similar studies and problem solutions, thereby fostering a cumulative research tradition. Documentation standards not only refer to the formal structure of scientific publications, but also to minimum requirements concerning content and presentation.
4. *Systematic promotion of problem solutions*: New problem solutions that can be applied efficiently while also being effective require adequate promotion, so that practitioners can become familiar with them. Organizations that provide standards should actively engage in such promotion activities when efficiency and effectiveness has been proven with methodological rigor and empirical evidence. Problem solutions that do not meet these high standards should not be promoted.

4. A framework and guidelines for conducting prescriptive PM research

As the previous sections have shown, prescriptive research is about far more than simply creating an artifact as a solution to a practical problem. In order to help researchers set up and conduct their prescriptive PM research, we will now propose a research framework, accompanied by recommendations outlining what steps are necessary to satisfy scientific and professional requirements. The framework we propose conceptualizes the entire prescriptive research process, starting with a practical problem to a documented and communicated solution to this problem (Fig. 1 and Table 3). Within this process, we distinguish between the 'solution' (either a procedural model or a solution template) that is intended to solve the project-related problem at hand and 'propositions' describing how and why the PM solution works and yield the desired outcomes. The solution and propositions are subsequently referred to as the 'prescriptive research result' or 'result.' The development and corroboration of the research result is achieved by means of a four-step research process described in the following section.

4.1. Problem analysis

The research process commences with an in-depth investigation of the project management problem the researcher wants to solve. To qualify for such an investigation, the problem needs to fulfill the following criteria:

1. *The problem is clearly defined*. The researcher is able to clearly describe the problem in terms of constituent characteristics, observables indicators, and unwanted consequences.
2. *The problem is practically relevant*. The relevance needs to be proven or at least convincingly presented. Clear empirical evidence should substantiate the relevance.

3. *The problem needs to be solvable*. Not all problems can be solved by clear procedural guidelines or by a solution template. For example, social or cultural problems are harder to address this way (if at all).
4. *The problem has not yet been solved to a satisfactory level*. In many cases, several solutions to a problem exist. Developing a new one is legitimate when the existing ones are unsatisfactory or a new one delivers significantly better results.

During the problem analysis phase, the researcher analyzes this problem iteratively using the existing theoretical body of knowledge (i.e. existing theories and research) and the available empirical data (e.g., interviews, statistics). This process step assures that researchers have a thorough understanding of the problem, since only this understanding will enable them to build a solution that addresses the underlying roots and causes.

Theories are pivotal in this process, because theories offer constructs and causal relationships that may explain why the problem occurs, how it occurs, and what its consequences are. For example, theories from psychology may explain phenomena like resistance or motivation. Theories from sociology may enhance our understanding of group dynamics, while theories from the natural and engineering sciences may help us with the planning and controlling of problems. In general, theories have a threefold role (Kerlinger, 1973): (1) they structure the problem by offering constructs to describe it, (2) they explain the problem by offering causal relationships between these constructs, and (3) they provide us with problem solutions ideas because of their predictive power.

In some cases, we simply do not have theories at hand that can guide the problem analysis. This may be an indicator for us that there is limited theoretical understanding of the problem. To overcome this problem and fill the gap of theoretical understanding, the research might seek to collect empirical data or to draw on existing data for further analysis of the problem. It might even be the case that the empirical data do not match theoretical predictions, which means that the problem is also of particular theoretical relevance and requires further research.

Using theories and empirical data during the problem analysis phase are not mutual exclusive options. In many cases, problems have many facets, and some problems may be well explained by a particular theory, while others call for empirical work. Both approaches have the same objective: they allow for the formulation of (preliminary) propositions describing the problem's nature and its solution. Such propositions—the output of this first process phase—are very important, as they (1) can guide the solution design, acting as meta-requirements for the desired solution, (2) form the foundation for the later evaluation of the solution, since they can be translated into testable hypotheses, and (3) may serve as a starting point for building new substantive theories that extend our knowledge of the problem domain.

4.2. Solution design

At the solution design stage, the researcher designs the solution based on the propositions of the preceding phase. During this activity, the researcher will translate the propositions, which serve as meta-requirements, into different methodological

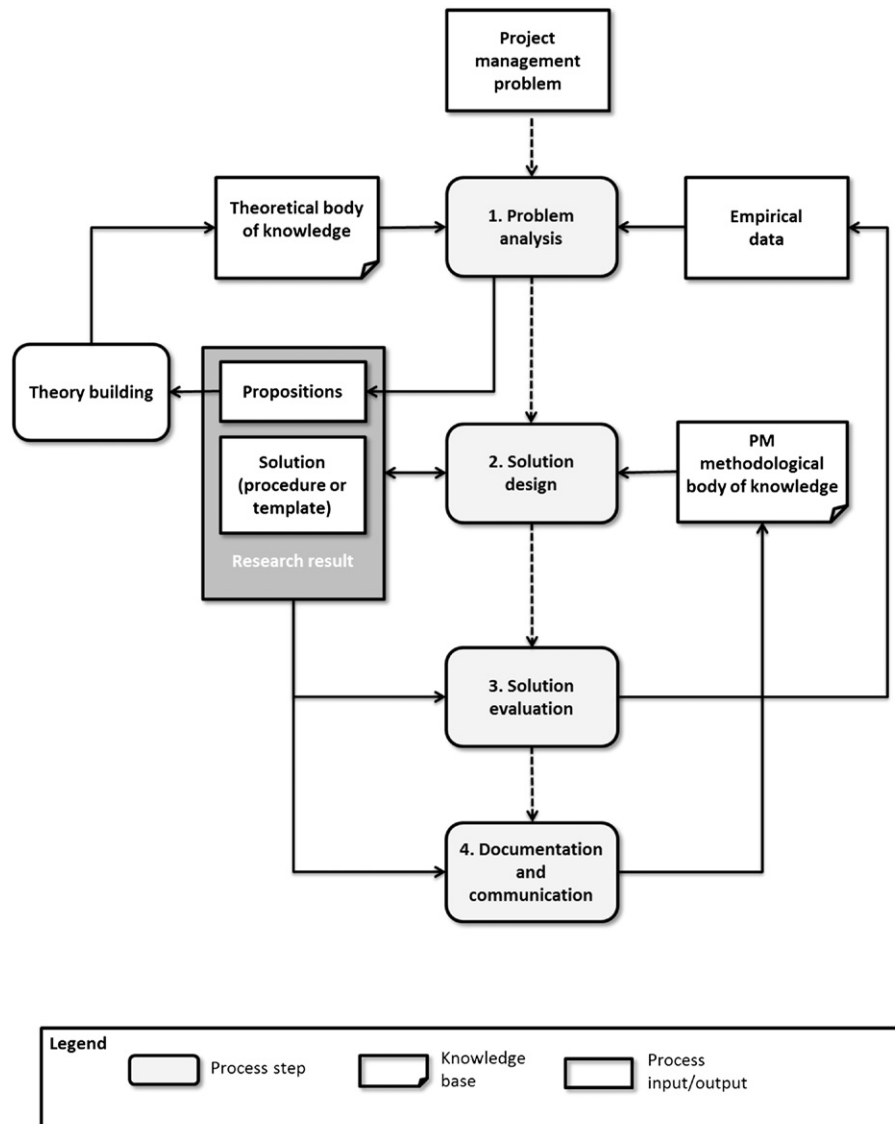


Fig. 1. Framework for the development of PM methods.

alternatives. In this step, the researcher will already test the design alternatives, albeit not as rigorously and systematically as in the subsequent solution evaluation phase. Preliminary testing allows a researcher to identify superior design alternatives and provides the opportunity to identify the potential for refinement and improvement. Throughout this cyclical process of solution design, the researcher will also revise the set of solution-related propositions, since each testing will either lead to new propositions or to the rejection of existing ones.

Solution design is a creative process, and a variety of sources may inspire the researcher. Perhaps the most significant among these sources is the existing project management methodological body of knowledge (i.e. the set of all existing PM methods), because many prescriptive research endeavors will seek to improve existing methodological approaches, rather than developing completely new ones. This is an accepted and adequate practice as long as the solution improvement is innovative and yields a significantly better outcome than established ones. A

stepwise improvement of a class of solutions will also add to a coherent and cumulative body of knowledge, which project management still lacks at present. Nevertheless, some researchers may opt for other sources of creative stimulus and may want to borrow ideas from action-oriented neighboring disciplines or even from the natural sciences. The latter can provide blueprints for the solution design like neural networks (de Barcelos Tronto et al., 2008; Sanchez, 2005) or genetic algorithms (Alcaraz and Maroto, 2001; Hartmann, 2001) that have already successfully been transferred to the project management research domain.

By the end of the design phase, the researcher has developed (1) the solution itself and (2) a set of revised propositions related to the artifact.

4.3. Solution evaluation

As in evidence-based research, a solution needs to prove its quality by means of thorough evaluation, the purpose of which

Table 3
Guiding principles for the research framework.

Research phase	Guiding principles
<i>Problem analysis</i>	- Clearly describe the problem - Check for the fulfillment of the problem criteria - Search for theories explaining the problem; consider neighboring disciplines where necessary - Decide on your result type: solution process or solution result - Formulate preliminary propositions describing the problem and potential solutions to the problem
<i>Solution design</i>	- Apply existing solution construction methodologies or design a new one - Develop and refine testable propositions describing how the solution solves the problem - Consider solution mutability
<i>Solution evaluation</i>	- Follow a cyclic evaluation - Move from more controlled testing environments (e.g., simulations) to more open testing environments (e.g., case research, action research) - Collect clear empirical evidence of the solution's usefulness and viability - Apply benchmarks where possible - Complete when no further improvements can be realized or the solution outperforms existing solutions to a satisfactory level - Identify new theoretical insights gained from the evaluation phase and communicate them, allowing for an extension of the theoretical body of knowledge
<i>Documentation and communication</i>	- Specify all information necessary to make an informed decision about the solution's application - Specify all information necessary to apply the solution - Document the solution for academia and practice - Communicate the solution to both academia and practice - Initiate training and standardization

is to (1) assure its effectiveness prior to its use in practice, (2) understand the conditions under which the solution works, and (3) identify the needs for improvements. Evaluation means that the solution is tested, either in a controlled environment or a real-world setting by applying it, observing its use, and collecting data on the outcomes. This data subsequently forms the basis for a systematic assessment of strengths and weaknesses, especially in comparison to existing solutions. This calls for benchmarks, which are already available for some project management problems, for example, optimization problems in the area of time management (Demeulemeester and Herroelen, 1997) and resource management (Welch and Shirazi, 1999). Some general quality criteria are available; researchers can translate these into specific metrics for their individual solution: a high-quality solution is innovative, yields superior results, is of high usability, offers a high reliability, and can be applied flexibly (Table 4).

Besides these general criteria, the propositions formulated in the previous design phase may be translated into hypotheses that are tested in the evaluation phase. In doing so, the researcher can verify whether the solution works as it is intended to work. Insights from this kind of analysis are especially helpful for further improving the solution, which is why the evaluation is not a once-off activity, but may be carried out several times as part of

Table 4
Quality criteria for a good solution.

Criterion	Description
<i>Innovation</i>	The problem-solving approach should be new and should not have been applied to the problem domain before.
<i>Performance</i>	The solution should reveal better results when compared to already existing solutions.
<i>Usability</i>	The solution should be easily comprehensible and applicable. It must be possible to use it in real-world project management environments.
<i>Reliability</i>	The solution's results should be replicable, i.e. applying the solution twice under similar conditions should lead to similar or identical results.
<i>Flexibility</i>	It should be possible to adapt the solution to meet particular requirements, which allows for broader application.

a cyclical process of design, evaluation, and refinement. Every time evaluation activities reveal improvement potentials for the PM solution under investigation, a new refinement and evaluation cycle is required. In order to determine whether this process has reached its end or whether a further iteration is required, the researcher can apply two criteria. The evaluation can be regarded as exhaustive when (a) the solution is significantly better than other comparable solutions (see above), and (b) the last evaluation round has not offered any insights that would allow for significant further solution improvements (Van Aken, 1994).

By evaluating the solution, researchers can gain new theoretical insights about how and why it works or does not work. This new data can be used for a new, more detailed problem analysis, which – in turn – may stimulate a new solution design and evaluation round by means of refined propositions. Revised propositions may finally lead to the development of new theories (as indicated in Fig. 1).

4.4. Documentation and communication

The success of prescriptive research depends mainly on the adoption of its results. One could argue that the success of prescriptive research could depend on other factors, such as the way it stimulates other research. Nevertheless, we believe that, primarily, prescriptive research should be relevant (Hevner et al., 2004), especially in an action-oriented discipline such as PM, and that the adoption rate is a good relevance indicator. To realize a high adoption rate, researchers must document and communicate their research results in such a way that professionals can easily apply them in practice. However, the needs of practitioners differ significantly from those of the scientific community, due to divergent prior knowledge and intentions. Once the evaluation results are conclusive, the researcher should therefore document the solution in two distinct ways: Practitioner-oriented publications should provide all the information necessary for professionals to make an informed decision about the solution's application and for them to be able to apply it correctly. Scholarly publications should also contain all the information necessary to allow for the verification of results as well as the stimulation of further research (Gregor and Jones, 2007).

Despite clear differences, both publication types need to include comprehensive information about the problem and its solution. Besides the fact that the solution itself should be documented in its entirety, it is also advisable to make clear statements about the conditions under which the solution applies and does not apply. Both professionals and scholars should be able to understand what the immediate results of the solution are and how these translate into desired benefits.

After a solution has been documented and published in a way that it is accessible to practitioners and scholars, it may take time before a solution's adoption becomes observable and its application gains momentum. When the continuous application is successful, the professional community can further leverage the solution by including it in standards and norms, which will not only foster its recognition but will also make it a part of individual and organizational competency baselines as well as training programs. At this stage, the solution has become a part of the established PM methodological body of knowledge.

5. Example: the case of the critical chain method

While a theoretical foundation and empirical validation might be lacking for most PM methods, there are some exceptional cases from the PM discipline and neighboring disciplines that very well illustrate how theoretically and empirically grounded prescriptive research may be carried out (Table 5).

One such exception is the critical chain scheduling method (CC), which has attracted considerable interest in both practical and academic circles. We will use the critical chain method as an example that illustrates our framework's applicability. We chose CC because it is a prominent illustration of a project management method that is both theoretically and empirically grounded, and which competes with other more established methods. The ongoing debate around CC (e.g., Goldratt, 1997; Herroelen and Leus, 2001; Kim et al., 2008; Long and Ohsato, 2008; Watson et al., 2007) implicitly exhibits many of the tenets of our framework. We will not discuss the method or its

actual effectiveness in detail, but will rather explore its development and validation as a well-known and increasingly used PM practice, showing how incremental, systematic, and cumulative research based on theory and empirical evidence can lead to useful new PM methods. CC is a method for planning and managing projects that emphasizes the resources required to execute project tasks. From the outset, it has been positioned in contrast to the more traditional Critical Path and PERT methods, which emphasize task order and rigid scheduling. CC was introduced by Eli Goldratt (Goldratt, 1997) in the unconventional form of a novel. Due to this form, Goldratt's exposition of CC is rather unscholarly, appealing to the reader's common sense and experience, rather than basing his arguments on academic sources.

5.1. Problem analysis

Despite its unconventional publication form, CC's development is based on a thorough problem analysis rooted in empirical observation and theoretical interpretation. Classical scheduling approaches (e.g., CPM or PERT) were shown to be ineffective in many cases (Dodin, 2006; Jaafari, 1984). Goldratt attributed these problems to the fundamental characteristics of classical scheduling techniques. First, project team members tend to use individual work package buffers, whether they are needed or not, because there is a strong propensity to defer tasks to the last possible moment. Goldratt calls this phenomenon 'student syndrome,' but it is more commonly referred to as procrastination and has been thoroughly researched for several decades (Hill et al., 1978). Inquiry into this human trait dates back to the 1950s, when Parkinson first published his ideas on work and the time it requires. His work is usually cited in terms of Parkinson's Law (Parkinson, 1957) and has been applied to project management since the 1970s (Krakowski, 1974). Another formal analysis of its implications for scheduling has been done by (Gutierrez and Kouvelis, 1991). Goldratt recognizes that scarce resources are critical when developing viable project schedules. This matter

Table 5
Examples of theoretically and empirically grounded problem solutions from project management and neighboring disciplines.

Source	Discipline	Research objective	Theoretical and empirical grounding
Goldratt (1997)	Project management research	Develop a scheduling approach to overcome typical problems with work package buffers and task deference.	Grounded in psychological and operations research theory; there are significant studies available that empirically analyze the effectiveness of the approach under different conditions.
Mohamed and McCowan (2001)	Project management research	Develop an approach to model and rank various investment decisions in the context of construction projects combining monetary and non-monetary aspects.	Grounded in possibility theory and evaluated using historical data to perform simulations and to compare the results of the proposed approach with the results of another established method for project selection under risk.
Hanseth and Lyytinen (2010)	Information systems research	Develop an approach to design information infrastructures (like computer networks or electronic data interchange (EDI)), taking the problem that multiple parties are involved, the field is highly dynamic and technologically complex into account	Grounded in adaptive systems theory and evaluated empirically using the case of the Internet.
Tennyson and Cocchiarella (1986)	Educational research	Develop an advanced approach to concept teaching to reduce classification errors like overgeneralization or undergeneralization	Grounded in cognitive theories and instructional theories, and based on prior empirical research used for validation purposes.
Andriessen (2004)	Management research	Develop an advanced approach for the economic valuation of intangible goods based on a thorough assessment of 25 existing methods	Several case studies, grounded in existing prescriptive research and general theory on the valuation of intangible goods, were conducted to validate the findings.

has already been subject to his past work and is addressed in his theory of constraints (ToC), which can be interpreted as prescriptive research that explains how the allocation of scarce resources can be accomplished successfully (Goldratt and Cox, 1986). ToC has been influential in the scientific community and has been the subject of numerous studies (Kim et al., 2008; Watson et al., 2007). There are also signs indicating that other applications in PM are possible (Steyn, 2002). Fulfilling the criteria of good problem analysis, Goldratt took the *clearly defined* and *practically relevant* problem of how to generate a realistic schedule for projects. This problem has been shown to be *addressable with methods within the scope of project management*, but its *current solutions have proven to be unsatisfactory*.

5.2. Solution design

With theoretical underpinnings from different disciplines, Goldratt had a sound foundation for constructing his CC method, and which allowed him to develop a new scheduling approach that addresses the problem's roots. Goldratt's solution design was the result of comprehensive research efforts lasting several years. Most of his innovative ideas for CC emerged from his experience with ToC and its application in various scenarios. One of his method's most crucial and innovative ideas was to add all time buffers at the end of the project and plan individual tasks without buffers.

5.3. Solution evaluation

Goldratt did not include an explicit solution evaluation into his research process and provides only anecdotal evidence for CC's effectiveness. He left it to his peers to review and check his claims of CC's superiority over other task scheduling methods in projects. When CC started attracting practitioners' attention, scholars began to look closer at this new scheduling technique and undertook studies to investigate it. Thanks to these studies, we now better understand how, why, and when CC works. Benchmarks were applied to compare CC's performance to that of other scheduling approaches (Herroelen and Leus, 2001; Herroelen et al., 2002). Past studies also elucidate CC's weaknesses and how it can be improved. For example, the quality of the buffer estimation technique that is part of CC has been subject to debate, and suggestions have been made to improve it (Long and Ohsato, 2008; Rabbani et al., 2007; Tukel et al., 2006). Based on this increased understanding of CC, it was noted that CC cannot solve all project management problems, and that other methods still have their uses (Cohen et al., 2004).

5.4. Documentation and communication

In terms of documentation and communication, CC has experienced remarkable success. Numerous professional and scientific articles (see above), books (e.g., Leach, 2005) and press coverage (e.g., Globerson, 2000) furthered this method's dissemination. CC has been discussed at many conferences and events (e.g., international conference on quality in research Dachyar and Saputra, 2009, ICMIT 2000 Shou and Yao, 2002);

CC is increasingly finding its way into project management standards and norms (e.g., Project Management Institute, 2004). The method has also been subject to a number of refinements and extensions. For example, (Bevilacqua et al., 2009) developed a work package prioritization approach based on risk assessment, while (Shou and Yao, 2002) propose advanced buffer estimation procedures. Even more remarkable is that there is a clear theoretical 'backflow' of CC discourse fertilizing other domains, such as cost management and resource management (Steyn, 2001).

6. Conclusions and outlook

In this article, we discussed the nature of research in the project management discipline and diagnosed the field as being characterized by abundant prescriptive and conceptual research that often lacks a solid theoretical and empirical grounding. While perhaps not the only reason, we can conclude that this is one explanation for the low levels of acceptance, adoption, and success of PM research results. It often remains the case that professionals and researchers know too little about how prescriptive research results should be applied, when they are useful, and how they yield the intended benefits. A call for a more systematic, theory-driven, and empirically grounded approach to developing PM problem solutions seems a logical response to this problem. In this article, we have sought to learn from two of the more mature approaches to prescriptive research. We analyzed the discourse on evidence-based and design research to identify guidelines, principles, and lessons that also pertain to the PM discipline. We subsequently synthesized these findings into a framework that explains *what* needs to be done in prescriptive PM research and points out *how* these activities can be approached. We use the critical chain methodology as an example to illustrate our framework.

We regard our work's contribution to be twofold. First, we hope to stimulate discussion about more empirically and theoretically grounded prescriptive PM research, thus helping the discipline advance. Second, we offer the framework as a guideline for developing individual research designs. In general, researchers may apply our framework for any kind of prescriptive research project. However, they still have to make numerous methodological decisions, for example, regarding the solution design or the solution evaluation. Different kinds of construction, data collection, and data analysis techniques, based on potentially very different epistemological and ontological stances, may be applied.

Our framework may very well be used in "practitioner-driven" settings in which researchers and professionals jointly develop new approaches to project management problems. In this context, the framework can be easily combined with an action research approach (Avison et al., 1999) following a plan-do-check-act cycle. This would not only strengthen the validity of the results, but would also foster adoption.

At present, the proposed framework has not been evaluated following our own recommendations, which might be considered a limitation of our work. However, the case of the critical chain method, lessons from the neighboring disciplines, and our

own past prescriptive research experiences underline the framework's general applicability. Another aspect worth mentioning is that our work is a high-level framework that allows a researcher many degrees of freedom. This particularly includes the selection of specific design and evaluation methods. Neighboring disciplines offer a wealth of options here, and researchers may make their own methodological decisions, depending on the nature of the solutions they want to create as well as relevant contextual factors. No generally applicable framework can fully reflect the reality of diverse problem solutions and research scenarios. This reveals further research opportunities, because the PM discipline has, to date, offered almost no detailed methodological advice for prescriptive research. In this regard, our framework may by step into the direction of a proper research methodology for project management.

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