Identifying and Acting on Early Warning Signs in Complex Projects

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ABSTRACT ■

We consider identification of early warning signs (EWS) in projects. Project professionals are not good at detecting or acting on EWS. Barriers that lead to this are identified. The nature of EWS and their detection change with the evolving situation. Project assessments, typically part of gateways, are useful in identifying EWS connected to the formalities of the project. As complexity increases, assessments have more limited use, and the project is increasingly dependent on detecting EWS by informal "gut feeling." Thus, knowledge, experience, and communication skills are increasingly important in complex situations. We conclude with a list of early warning signs.

KEYWORDS: uncertainty; risk; early warning signs, project assessments

INTRODUCTION ■

We are often surprised at how projects turn out. Complex projects often do not behave the way we expect, and in particular, effects within complex projects are often time-delayed and take time to emerge. Project assessments (however called) are carried out worldwide, often to evaluate to what extent project documents are developed in accordance with expectations and formal criteria and to support decision making; these have to look through the complexity of a given project in its context and identify the relevant early warning signs (EWS) of project problems, project failure, underperformance, or cost overrun. Experience and current literature seem to indicate that we are not very good at picking up early warning signs.

This article reports a study of how project assessments may be used to identify early warning signs in complex projects (Klakegg, Williams, Walker, Andersen, & Magnussen, 2010). This research represents a project owner perspective. The study includes analyzing guidelines, interviews, and cases from three countries: Australia, Norway, and the United Kingdom. The focus is on well-established industries with traditional investment projects including development of some form of physical or digital infrastructure, typically construction, energy, oil/gas, telecommunications, and information and communications technology (ICT).

The study included a literature review as a starting point and this confirmed that we are in general not very good at picking up early warning signs. In particular, the literature points out problems related to three areas: understanding project risk and uncertainty; comprehending complexity; and detecting people's tacit knowledge and understanding how they respond and interact. There is no doubt, however, that project professionals and academics in the field of project management research do try to improve current practice by introducing new and improved methods and tools in areas like risk management, project planning and control, and project governance. There is an abundance of literature discussing aspects of how to identify uncertainties in project development, unhealthy conditions that may lead to problems later, and why projects do or do not perform as expected, as well as advice for improving performance in these aspects (for an overview, see Klakegg et al., 2010). This article does not take up this line of inquiry, but instead reports the empirical part of the study.

This article reports on a comprehensive exploratory fieldwork designed to look at how project owners actually install regulatory frameworks with project assessments, and discusses some aspects of the outcome. Owners' attempts to strengthen project governance are an attempt to identify early warning signs and act on them in order to secure successful projects. The authors take a

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closer look at these practices to find out how successful they are.

Studying complex interdisciplinary issues in real-life situations calls for a pluralistic approach. We chose critical realism as our starting point, since this encourages interdisciplinary research and allows us to use many different perspectives and methods in gathering and analyzing data. The study is inductive by nature and uses qualitative methods. We draw on information from project assessments and study these individually; however, in the overall study, the unit of analysis is the project—hence, the use of case studies in the latter part of the project.

First we looked into a selection of nine (public and private sector) governance frameworks to find out how frequently project assessments are made, and what the guidelines prescribe as good practice. This part of the study comprises document studies and interviews with key experts on these frameworks. To investigate the actual practice and to collect empirical evidence, we conducted semistructured interviews with 14 experts, looking at what companies and public entities do to implement project assessments, focusing on methodological choices and the effects of established practices (i.e., what they look for and how they utilize what they find). We followed this up with analysis of eight case projects to find out what the project assessments had identified as early warning signs and whether these had actually been confirmed in the time after assessment (i.e., whether the right things were looked for and action taken). The cases were chosen to represent the same categories of settings as used in the interviews to secure consistency in the material.

In this article, we choose to report specifically on our findings concerning the ability to identify early warning signs and act on them. The basis comes from research into how methods are designed to identify warnings, and why do they fail to detect early warning signs, how project assessments can

handle the complexity in projects and their context, which practices seem more appropriate in which contexts, and how identified warnings are acted upon.

Conceptualization

Early Warning Signs

An early warning sign is an observation, signal, message, or some other form of communication that is or can be seen as an expression, indication, proof, or sign of the existence of some future or incipient positive or negative issue. It is a signal, an omen, or an indication of future developments (Nikander, 2002).

Ansoff's (1975, p. 22) ideas of responding to "weak signals" stated: "A firm that wishes to prepare for strategic surprises has two options. The first is to develop a capability for effective *crisis management*—fast and efficient *after-the-fact* responsiveness to sudden discontinuities. . . . The second approach is to treat the problem *before the fact* and thereby minimize the probability of strategic surprises. . . . Both approaches deserve management attention." This article has a focus on early warning signs—the proactive approach.

Loosemore (1999, 2000) identified three types of crisis in a construction project management context. Perceptions of an impending *creeping crisis* present EWS that are understood but unaddressed until the crisis occurs. *Sudden crises* occur seemingly without warning, whereas *periodic crises* occur in cycles that may or may not be understood. Many crises appear without accompanied contingency plans—often being perceived as low probability but high potential impact events perhaps best tackled using an emerging strategy and having sufficiently skilled project management teams to recognize EWS and react appropriately (Mintzberg, 1987; Mintzberg, Ahlstrand, & Lampel, 1998).

This study, however, focuses on a project's front end, because establishing sound governance at this phase is so pivotal (Williams, Samset, & Sunnevåg,

2009). Accordingly, we also focus on project management governance frameworks because they are closely linked with project assessments that reveal EWS. A study of three existing frameworks in the United Kingdom and Norway (Klakegg, Williams, & Magnussen, 2009) showed how project assessments that are embedded within the governance structures operate effectively to identify EWS and address emerging problems. Detection of EWS can be appropriately designed into the delivery system. Balachandra and Raelin (1980) presented a model indicating that project success factors could be used for developing an EWS model—an approach supported by Sanchez and Perez (2004).

Types of EWS

Traditionally, project performance measures are lagging indicators, consequences of activities and incidents, not leading indicators that can provide more relevant and valuable information. The basic idea of EWS is to focus leading indicators; the question is where to look. Kappelman, McKeeman, and Zhang (2006) indicated that people-related and process-related risks scored higher than product-related risks as dominant EWS of IT project failure. Syamil, Doll, and Apigian (2004) argued that behavior-related performance measures evaluating project processes are mediating variables affecting the extent to which the given process contributes to the overall project result. Hoegl, Weinkauf, and Gemuenden (2004) found that collaborative processes during a project have predictive properties in regard to later team performance and can serve as EWS.

Cultural or disguised human EWS should not be overlooked. Understanding human gestures and expressed metaphors about lived experiences provides an important window into feelings and emotions (Whitty, 2010). These reveal many subliminal and hidden human EWS to project managers having the emotional intelligence to

sense unease (Dulewicz & Higgs, 2000). Often a workplace culture suppresses people's ability to express such fears. Unease can be measured through stakeholder engagement tools (Bourne & Walker, 2006) or surveys, particularly well-constructed employee feedback surveys (Lloyd-Walker, Lingard, & Walker, 2008). Providing anonymous access to whistleblowing procedures (Beauchamp & Bowie, 1997) is now becoming more common as part of a response to victimizing in the workplace (Dessler, Griffiths, & Lloyd-Walker, 2007, p. 128).

Interpreting human behavior is always a challenge. Nikander and Eloranta (2001) and Nikander (2002) presented an extensive list of types of signals, including "gut feelings" and "non-verbal information," as well as "differences and deficiencies in project culture" and "miscommunication," that identify potential problems. Recent work by Whitty (2010) discussed body language and cues that people naturally use to describe project management processes and how they feel about their project experience.

Project Assessments

Project assessments is a wide concept, comprising all types of appraisals and examinations of project documents and practices in order to support decisions, learn from experience, or ensure that expectations or formal criteria are met.

The main types of project assessments are summarized in Table 1. Oakes (2008) categorized assessments by frequency/formality, the type of review team (independent specialists or peer reviewers), and the focus of the review (business or technical). Assessments can take place at all stages of project development.

Our study included using a standard project model, including phases and development stages, similar to those used in general project management literature, as a reference. One typical element of project models with an owner perspective is "gateways" or "stage gates." Literature on the stage-gate approach and how it aims to pre-empt potential problems that make a project non-viable is well known (Cooper, 2005; Cooper et al., 1997; Office of Government Commerce, 2007). However, as Flyvbjerg, Holm, and Buhl cautioned (2002; also Flyvbjerg, Rothengatter, & Bruzelius, 2003), overoptimistic assessments of benefits and underestimates of risks can subvert this process as a way of flagging a possibly unsustainable project. The front end in a project life cycle is an effective time to look for early warning signs, but often these are purposely overlooked, as Flyvbjerg et al. suggested, or they simply are not envisaged. Later, during project delivery, periodic reviews may assess risks, progress, and indicators of development. Sometimes that occurs in response to identified potential or real problems through audits, health checks, or benchmarking exercises. This stage of a project's life cycle involves intense and distracting activity, and it is easy to miss EWS. Additionally, some actions may be too late to avert when the warning signals are acknowledged; the original warning signals may have been conveniently ignored or intentionally hidden.

Some assessments may be performed by the project planners and responsible executors themselves, but controlling and questioning one's own work obviously has its limitations. To strengthen the independence of scrutiny and credibility of the findings, the assessors are normally more or less independent of the project organization. They might be internal to the organization but are often all external experts.

Focused review systems and monitoring that can detect early warning signs through a governance structure is an integrated element in project management practices. Post-project reviews need to be comprehensive and context-rich (Williams, 2007). Postmortem analyses of unsuccessful projects also show that there are evident EWS well in advance of the final failure.

The Influence of Complexity

Intuitively, we would expect complexity influences the possibility to identify and act on early warning signs. Complexity includes structural complexity (Baccarini, 1996) and uncertainty (Turner & Cochrane, 1993). There is a large body of literature on project risk management, for the "known unknowns." However, much uncertainty comes from lack of a clear unambiguous goal (Engwall, 2002; Linehan & Kavanagh, 2004). Even when the goal is known, moving toward it can be a messy, uncertain process, as participants "make sense" (Weick, 1995) of the project and work toward project delivery. Problems within projects are often subjective and interpersonal, resulting from a team of people working uncertainly toward an uncertain goal with emergent complex team behaviors (e.g., Stacey, 2007).

Understanding the outputs or behavior from the input effects is difficult in assessing complex projects. According to Simon (1982), a complex system is made up of a large number of parts that interact in a non-simple way. The New England Complex Systems Institute (2009) stated, "The study of complex systems is about understanding indirect effects." The causal relations between early indications or incidents and later results are seldom obvious, and often very complex. Much project complexity comes from the human-oriented social aspects—projects have "behavioral complexity" as well as "dynamic complexity," making them "wicked" (Roth & Senge, 1996). Hence, in addition to internal complexities, such as technology and interfaces to existing systems, external complexities, such as stakeholder relationships (Pryke & Smyth, 2006), bring particular difficulties in understanding project behavior. Williams (2005, 2007) discussed how to draw lessons post hoc from complex projects, and the

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Project Assessment Type	Characteristics	Cited Authorities
1. Project reviews	Anchored in some sort of governance framework or institutional framework/decision-making process. Can be formal and mandatory. Often undertaken beforehand through a staged gateway approval approach, also during and after the project as benefits realization.	Archer and Ghasemzadeh (1999); Office of Government Commerce (2007); Cooper, Edgett, and Kleinschmidt (1997); Cooper (2005)
2. Project health checks	Often implies a more formal assessment, sometimes looking for fraud, often during the project, sometimes at set stages or ad hoc if particular issues need investigation. Usually checklists and key performance indicator (KPI) performance reports can be used (and similarly, front-end constructability reviews and value analyses in infrastructure-type projects).	Health checks: Shafagi and Betts (1997); Construct IT Group (2009); Wateridge (2002) (looking at the stakeholders' view of project success) Constructability: Griffiths and Sidwell (1997); McGeorge and Palmer (2002) Value analysis/engineering: Champion (2001); Male, Kelly, Gronqvist, and Graham (2007) Diagnostics: Jaafari (2007)
3. Benchmarking	Systematic comparison of two or more projects, analyzing quantitative (cost/time information, technical evaluations, etc.), and/or qualitative (objective formulations, stakeholder assessments, environmental impact descriptions, etc.) aspects of project performance. Typically used to compare project proposals competing for scarce resources to determine which is most likely to succeed, or to obtain realistic estimates, learn how other projects or organizations have solved certain problems, or rank projects after completion.	A major application of benchmarking to projects was done in the IMEC project, started in 1995 and documented in Miller and Lessard (2001). Emhjellen (1997) discussed the adaptation of industrial benchmarking to project benchmarking. The Project Definition Rating Index (PDRI) is a tool for benchmarking (Construction Industry Institute, 2009). Independent Project Analysis (IPA institute) has developed tools and databases for benchmarking projects in several industries, including oil and gas, process industry, and mining (www.ipaglobal.com)
4. Post-project evaluations	Occurs after the project as a project history, usually with the goal of extracting lessons learned. Sometimes initiated as part of resolving conflicts.	Project histories: Kleiner and Roth (1997); Roth and Kleiner (1998); Schindler and Eppler (2003); Williams (2007) Literature and focus on knowledge chains: Maqsood, Finegan, and Walker (2006); Maqsood, Walker, and Finegan (2007)
5. Project audits	Formal assessment checking accordance between what is done and regulations, decisions, or systems, sometimes looking for fraud. Often during the project, sometimes at set stages or ad hoc if particular issues need investigation. Sometimes ex post. In many circles, the word "audit" has a quite specific meaning, sometimes enforcement by law.	For example, the UK National Audit Office

Table 1: Summary of the main types of project assessments and associated references.

difficulty of this in predicting the behavior of complex projects; the difficulties mid-project are even more apparent.

Guidelines for Project Assessments

The study looked at established governance frameworks and their guidelines to consider what is considered good practice and to check whether these specify what to look for in terms of early warning signs. Nine frameworks were

studied, representing both the public sector (six frameworks) and the private sector (three frameworks) in Australia, Norway, and the United Kingdom, and representing a wide variety of approaches, methods, and structures, some general, some complex, and some control-based.

The study report (Klakegg et al., 2010) presented examples of the governance frameworks and the use of project reviews incorporated in them. We found that these frameworks are very common and that project assessments in some form are obligatory in most of them. They are also reported to be effective. We found some differences between sectors. In the private sector, the frameworks tend to be more internal and integrated with other systems, and the decisions attached tend to be assigned to a smaller number of people. The division between governance and management is often not so clear in the private sector. In the public sector, there are normally fewer stage gates and a more external procedure. Governance and management tend to be more clearly divided.

Roots of problems in later project phases are found in processes and decisions at the front-end of projects. Issues that arose in the study of governance frameworks included:
• Issues of public policy and market shaping (Office of Government Commerce, 2010a)
• Initiation documentation and the business case (Office of Government Commerce, 2010b), or not being able to answer fundamental questions: What is the project aiming to achieve? Why is it important to achieve it? Who will be involved in managing the process and what are their responsibilities? How and when will the project be undertaken?

But it remained a moot question whether the project reviews are able to detect the important EWS. It is obviously a fundamental assumption that they do. Several guidelines mention detecting early warning signs as one of the purposes of assessments. The owners of these frameworks are clear in their judgment: they report that these frameworks are successful and deliver results as intended. Our research indicates this is true, but also that the assessment approach has limitations as to what kind of EWS they are able to identify, and whether the results can be considered early warning signs is a question of whether they can be detected early enough. The framework guidelines also do not generally specify which early warning signs to look for.

Assessments in Actuality
We interviewed 14 respondents, evenly distributed among the three countries, about their experiences of governance frameworks, assessments, and early warning signs in order to get closer to the reality behind the current practices. We provide details of those interviewed and our rationale for the study elsewhere (Klakegg et al., 2010).

Context and Experience
First, we asked about the definition of the early phase. This definition varied across the organizations interviewed, with a differing degree of specificity in the definitions, ranging from more informal boundaries to more concrete points in time. The end of the early phase seemed more pronounced, marked by formal approval at predefined gates.

Regarding the use of gateway and phase models, most private and public sector organizations had (more or less) clearly defined gateway models, but some did not, and there seemed no pattern to predict which type of organization would have implemented one. The models ranged in extent from only two gateways in some public sector regimes to five, six, or more in some public and private sector models. Transition from early phase to project was in almost all cases dependent on a formal approval or decision by someone mandated to sanction that transition, such as executive management, accredited reviewers, the client, or politicians. Internal resources were usually involved, but with a strong presence also of external resources, typically consultants or other types of advisors; there seems to be a tendency for external resources to be used more when the gateways are considered formal ones.

Current Practice in Project Assessments
All organizations had a range of various assessments, applied in all of the project phases throughout the project life cycle. Areas addressed included:
• Stakeholders, through more or less formalized analyses
• Political processes and understanding that led to the decision to pursue the project
• Technical viability and "deliverability" of the project
• Risks and opportunities, perhaps the most obvious source of early warning signs, as risk elements are per se issues that could cause problems and therefore need to be monitored
• Resources to perform the project
• Cost estimates and "affordability"
• Business case development
• Environmental impact analysis
• Benefits and "value for money"

Documents supporting the assessments included technical and financial documentation, reports from external consultants, and different checklists (the documentation in each case depending on the issue in focus in the actual assessment). Some interviewees mentioned that assessments also relied heavily on interviews and/or discussions with key people. Common approaches to executing the assessments included group discussion sessions, interviews with individuals, peer reviews, observations in meetings, and completing checklists.

Identifying Areas for Early Warning Signs
The main impression was that although many attempts are made at learning from previous projects, this was rarely

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very effective. The reasons cited ranged widely: no time to prepare lessons learned, reluctance to "air dirty laundry," projects view themselves as unique so one can learn very little from past projects, and reports that are short enough that people will read them lack sufficient information about the project context to enable real learning. One respondent summed it up as follows: "There are many lessons identified, but not very many learned."

We did, however, learn of some practices that might help make lessons learned more useful: consistently writing down insights understood during a project, to ensure remembering them; senior managers appointing project managers indicating which previous projects (and thus lessons learned) might be relevant; new projects being proposed for execution having to review at least three similar projects to assess whether lessons learned apply to the new project; and bringing in external assessors, as they see many projects in many different organizations, and so represent an efficient means of experience transfer.

There were several suggestions about how post-project lessons learned can be used to identify early warning signs. Reports can contain information about problems experienced that could be used for early warnings in the new project. The likelihood of picking up on such issues appeared to increase if lessons learned were presented orally. Access to corporate expertise was mentioned as important. Bringing in external views into the project group is helpful. Converting lessons learned/post-project reviews into either specific checklists of possible problems or more open lists of possible areas of concern can provide new projects with direct sources of EWS.

When asked about early warning signs of complex projects, in addition to "hard" issues such as technological development, the interviewees also mainly identified softer issues such as culture, the lack of an outsider's

view/perspective on the project, anchoring in the permanent organization, lack of consistency between stakeholders' ambitions, and certain organizations promoting one solution and trust, as well as more "gut-felt" signs, such as detection of unrealism, lack of clarity of thought, or misalignment between quantitative risk analysis and qualitative risk assessments. We use the term *culture* as meaning patterns of human behavior and knowledge, shared attitudes, and values in a group or an organization. Contextual factors (factors outside the project scope and control span) were mentioned as an important source of complexity, including:
- Location decisions and complications arising from such decisions
- Leadership issues
- Quality of information and documentation produced
- Whether guidelines for early phase assessments and "behavior" are followed
- Relevance of the proposed solution compared to needs
- Culture, and whether specific conditions exist that will make cultural aspects a factor
- The need for development of new technology
- Main risks identified
- Lack of competence in the project team
- Sponsor with unclear expectations and role

Unexpectedly, these factors are mainly not really contextual: they are about the decisions and actions performed within the project or organization. It may be that the respondents are closer to these factors than the really contextual ones (a warning sign in itself), or the respondents may have focused on projects' responses to the really contextual factors, so focusing only on what projects can influence.

One interviewee in particular pointed out the assessors' role and ability to see the early warning signs. Some people are focused on details, while others

are preoccupied with the bigger picture. The ability to reflect on what happens in a project is crucial, for sponsors, project managers, team members, and assessors, and this requires both ability and time.

Early warning signs might arise in the interaction of issues and problems ("knock-on effects"). A few respondents (private and public sectors) confirmed that such interaction is often seen ("issues tend to come together"). This is particularly so if one overlooks a problem, as some other issue may come up that combines with the already unsolved problems to make things worse. "Knock-on effects" can also be caused by "silo thinking," whereby different parts of an organization work toward their goals, not understanding that their actions influence other parts of the organization, ultimately causing different problems to combine. Respondents were not clear why such knock-on factors are hard to identify, except that it is difficult to provide project managers with enough time to think ahead about such potential problems, and we need to make people in projects question assumptions.

The Use and Usefulness of Early Warning Signs

We looked into the use of previously identified early warning signs at a later stage in a project. One public sector organization said that such signs change so much over time that they end up not being used very much. This is in sharp contrast to a private company that has implemented a balanced scorecard approach, including early warning signs as one set of indicators, assessed in regular meetings held at intervals of several weeks. Another private company employed a similar approach based on "traffic lights" for risk elements identified as early warning signs, again reviewed regularly. Three project management consultants all concurred that EWS that originate from external project assessments are "stronger" than those based on internal

ideas, both because the external assessments carry more weight and because the sponsor will be aware of them. One consultant said that such signs are most effective if they are included in the project reporting system; that is, reports to the stakeholders must include an assessment of the status of problem areas expressed in early warning signs. One private company had tried to institutionalize common early warning signs and lessons learned by modifying the stage-gate requirements to ensure that such issues were properly addressed.

We also asked to what extent insights gleaned from undertaking various assessments enabled identification of future problems in both the project and the project's business setting. Answers were not conclusive; a private sector project owner claimed the analyses and assessments made were sufficiently good that no major surprises turned up later in the project (minor issues could occur, but would never cause the project to run "beyond 110%"). Two project management consultants, on the other hand, posited that such assessments are currently not good enough, although they have improved over the years. In particular, there seems to be missing a guiding framework or checklist to aid this work, and there seems to be a natural tendency to focus on the solutions and contents of the project in the early phases (engineers focus on technical issues and economists on the business issues, but no one focuses on the project execution).

A key issue in this study is to examine how useful EWS are in foreseeing problems (and enabling action on such predictions). At least five respondents (private and public sectors) claimed that the use of EWS had been useful in preventing problems, with one of the private companies saying that the performance of their projects had gradually increased over the last two to three decades, in part due to their use of balanced scorecard early warnings. Others were not as unequivocal; one private

company said reviews of early warning signs can detect problems but cited an example where the review came three months later than it should have. One respondent from the public sector said that EWS are often not well articulated and, further, that the most difficult part is interpreting the EWS that occur—in some cases, with hindsight, it is realized that the signs were actually picked up but were not acted upon. This was echoed by another public sector interviewee who said that the organization was good at identifying early warning signs but poor at letting the signs affect decisions. Especially in the cases where the early warning sign is a "sense of uneasiness," it is difficult to induce action. The interviewee suggested it can be very difficult to justify the feeling; thus, people are reluctant to report it, even if the feeling later proves to be true and something is in fact wrong.

With some dissension in terms of the usefulness of early warning signs, we looked into what causes the less-than-hoped-for effects. The respondents provided various explanations:
• Overly ambitious plans—these are very difficult to detect.
• This is similarly true for the development of new technology and associated difficulties.
• Even when early warning signs are picked up, projects are very difficult to stop. Even when the concerns are documented, the project response is usually to assure that things will be all right and that they "will run even faster," thus effectively countering warnings.
• Especially with complex projects, it is difficult to identify all relevant early warning signs; hence, the problems that do materialize are things not covered by them.
• People involved in governance discussions and high-level project management discussions have often become too senior to have recent and relevant experience from operational matters, and consequently fail to address these in early warning signs.

• There is a tendency for group thinking, where ideas novel to the team's collective thinking and experience will not surface.

Given that there are problems in using early warning signs effectively, we finally asked what could be done to remedy this situation. One private sector respondent said we need more discipline in actually using the early warning signs once they have been identified. Another said that a too "heavy" process for identifying early warning signs could be an issue; it stifles creativity and thus fails to uncover all relevant warning signs. A public sector suggestion was to repeat relevant project assessments and the exercise of finding early warning signs several times throughout the project. The project management consultants pointed to the need for a formalized process for finding early warning signs, asking the right questions, and bringing in people with the right competence in the process, including someone "thinking outside the box."

Analysis of Case Studies

We looked in depth at eight cases, spread across a number of domains and in three countries (see Table 2), to see how early warning signs were detected in practice, which particular signs were noted, the usefulness of the detection systems, the effects of complexity, and how the early warning signs were used in performing these projects. Next, we analyzed some aspects across all these case stories. Points taken from the case studies are identified in the text by the reference shown in Table 2 (e.g., [N2]).

The selection of eight cases in three countries has enabled us to cover many dimensions, because we have been able to look into projects from different industries, both public and private sectors, and with different degrees of complexity. While it is perfectly normal that projects are dissimilar—most project definitions state that projects are

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Reference	Country	Domain	Description	Sector	Complexity
N1	Norway	Oil and gas	Large oil and gas field development	Private	High
N2	Norway	Civil/Development	City development focusing on the main part of the road system	Public	High
N3	Norway	Building	Private sector building project—shopping center	Private	Medium
N4	Norway	Building	Public sector university campus building project	Public	Medium
N5	Norway	ICT/Technology	ICT system development and implementation in a highly political environment	Public	High
U1	UK	ICT/Technology	Software development and Implementation within government department	Public	High
U2	UK	Process plant	Highly complex public sector process plant development	Public	High
A1	Australia	ICT/Technology	University IT services	Public	High

Table 2: Overview of the case studies.

unique and temporary—these projects are not only difficult to analyze because of their different sizes, complexity, and task uniqueness, but they are carried out against highly differing contextual backgrounds and different regulatory regimes. Clearly, a summary of lessons learned from such cases has to focus on the most important, and on those that seem to be relevant above the level of the single project. Documentation was used as examples and evidence of the issues discussed, but the main source of these findings was interviews with key people in the case projects.

About Project Reviews

Generally, the case studies showed the reviews to be useful. Some examples: Major external reviews are useful in providing reassurance and for giving projects stronger legitimacy [N4]. [U2] showed the usefulness of a "bring out all your dead meat" attitude. It also particularly showed the usefulness of partnering workshops. Assessments are an element both in developing and identifying the need for new knowledge and working practices [N5], although the

transfer of knowledge into the permanent organization is more difficult [N5].

However, reviews need to be well focused: While in [N4] stakeholder assessments to identify needs and priorities dominated the beginning, some misdirection of attention was identified. [N2] in particular warned against a focus in uncertainty analyses on "obviously" important issues such as detailed technical matters, construction market, progress, and so forth, which mirrored already identified problems, but which do not identify weak early warning signals of future problems and might not actually be the most important. In [N4] also, technical assessments dominated the engineering and construction phases.

What Was Good Practice or Practice That Seemed to Work?

Organizations and project teams approached the task of detecting early warning signs in different ways. There were a number of examples of good practice, or at least practice that seemed to give good results. In general, the formal exercises were found to be

useful. [U2] found the organization's gateway process useful. [N1] found the early warning signs exercise useful—but it was the exercise itself that was useful, rather than the indicators. [U2] demonstrated that problems can occur following a stage gate if a project proceeds after the gate with an unresolved issue. [A1] found that a "Quarterly Program of Works Review" of all projects allowed for decisions to kill projects—which avoided the situation of a project running adrift (with early warning signs pointing to failure) would be left to continue despite feelings of unease by many of those delivering the project. [N3] made the important point that efforts must be made to revise early warning signs frequently and keep them "fresh" in people's minds.

But rather than—or as well as—formal assessments, dialogue is key. Everyday communication and the work situation are better at identifying early warning signs than assessments [N2]; building trust and good communication is a good alternative to extensive use of assessments [N4]; warnings resulting from detected early warning

signs were initiated through dialogue [N4]; and in particular, more important than assessments as a source for early warning signs was the dialogue with the stakeholders and the technical observations during a parallel development process [N5]. Indeed, interestingly, "project participation satisfaction" became a valuable "thermometer" of the climate in the project [N1].

Outside the project team, organizational culture is important. Encouraging a culture where eagerness to develop projects and to acquire contracts is balanced by critical assessments of projects' viability was seen as important [N3], as was the idea that an appropriate organizational institutional support that gives authority enhances the likelihood of trust and commitment [A1]. Moving beyond the immediate organization, competence and knowledge about relations and stakeholders grow more important as the project's criticality increased; the project team's ability to master these relations became essential to project success in [N5]'s particular

situation. Moving from a technical approach by way of a project management approach into a relational and politics approach was seen as valuable [N5]. Indeed, in a highly political environment, playing actively in the political arena and being a strategic actor was seen as appropriate [N5] and developing a collaborative culture across organizational interfaces.

What Early Warning Signs Were Detected and/or Acted Upon?
Generally, all of the case studies (not surprisingly) failed to pick up some of the early warning signs. But some particular points that arose in the case studies can be summarized as shown in Table 3. The important point indicated in the table is the differences between stages of development.

Some additional observations:

[A1] shows the fundamental mismatch between project life cycles and strategic planning life cycles. This means that business might insist upon a year-on-year cycle of resourcing and

project sanctioning when projects are likely to stretch over several year-end periods. In this case, the initial weakness of this mismatch was recognized, and from 2009, a five-year strategic planning cycle was adopted.

The sponsor is also important, with sponsor abrogation of responsibility for maintaining focus and interest in the project [A1] and poor quality support from the sponsor to the technical team during project development [A1] both being early warning signs of problems. Also, the qualities of the team provide early warning signs, whether through poorly synchronized technical and business knowledge [A1], poor quality technical support while the application is bedded down at the implementation stage [A1], or technical or business capability maturity mismatched or lower than required [A1].

The case studies clearly indicate that reviews and decision points (stage gates) are useful. In [N4], first bids showed the cost frame would be exceeded. This led to changes in the

At project setup	In early stages	During project execution
• Vague or unclear reasons for undertaking the project (unclear thinking) [A1] • Poor project definition—lack of clarity of how the project's rationale, goals, and benefits fit into the Program of Work (unclear description) [A1] • A poorly developed business plan [A1] • Poor definition of the scale of what is needed, what resources are needed, and what assumptions are valid about the project [A1]	• Lack of a good business case [U1] • Deterioration of relations between the participants starts to occur, particularly for complex projects [U2] • Letters exchanged between main parties showing there was not a common definition of what one party's responsibility is [U2] • Danger of the project team overrelying on (the contractor's) IT people in an IT project [U1] (similarly in other industries) • The way answers are given to critical questions when the answers are vague [N2]	• Lack of documentation [U2] • An excess of "no cost no time" effects [U2] • Vague answers to critical questions [N2] • When people work too much or too little [N2] • Constant churn of people in "acting positions" with no authority to recommend action [A1] • Continually unfulfilled promises, frequently changing decisions, or lack of commitment to make decisions [A1] • Problems arising from letting a major subcontract in a specific complex domain to a contractor unfamiliar with the domain [U2] • Level of subcontractors' claims and extension of time claims [U2]

Table 3: Important early warning signs by time period.

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concept and a reconsideration of contract strategy. An extension of the bid-consideration period was initiated before commencing.

Barriers to Detecting Early Warning Signs Identified

Certain possible barriers to the detection of early warning signs were identified. Flyvbjerg et al. (2002, 2003) pointed out that optimism bias in both underestimating costs and overestimating benefits is an important barrier to taking in early warning signs. Optimism will generally make the actors de-emphasize possible warning signals [U1] [N2]. Optimism also occurs in the external client [N3], and indeed in a helpful contractor [N3]. Other barriers are organizational. These include organizational complexity in the environment of the project presenting barriers to detecting early warning signs [U1], or simply not having a clear strategy [N5], or not being able to clarify and solve conflicts over goals or strategies [N5]. Finally, there were some barriers identified in the review process itself, including defined pre-assumptions in predefined formal assessments, preventing openness to early warning signs [N4], the opportunity to select areas for focus in gateway reports might make it possible to hide signs of problems [U1], and a belief that the project assessments would capture all problems preventing recognition of other early warning signs [N1]. We need to consider such barriers when trying to improve performance when implementing governance frameworks and project assessment methods in practice.

Assessments or "Gut Feeling" Approaches: Possibilities for Early Detection

Above we saw that many early warning signs are of a less measurable nature and thus depend on more "gut feeling" approaches. The case studies gave an opportunity to look for signs of this phenomenon and identify further possibilities for early detection of early warning signs based on soft atmospheric or "feeling" issues. The main

Through assessments	Based on "gut feeling"
• Numbers/information missing [N5]	• Lack of a culture of openness and good communication between the actors [U1]
• Assessments not performed/documentation not completed [N5]	• A strained atmosphere [N5]
• Plans and reports too late and/or not clear [N5]	• Are the needs real? [N5]
• Contract obligations not fulfilled [N5]	• Inconsistent arguments about agendas [N5]
• Milestones/activity definitions unclear or missing [N5]	• Changes in position over time [N5]
• Lack of an implemented governance framework [N5]	• Uneasy comments and body language [N5]
	• Stating uncertainty, unwillingness to conclude [N5]
	• What kind of information they are willing to share [N5]
	• How they ask questions and how they answer [N5]
	• Making reservations [N5]
	• Not showing trust in the project organization [N5]

Table 4: Additional important early warning signs from case studies, sorted according to the way they are expected to be detected.

findings compared to typical "assessment-based" approaches are summarized in Table 4, comparing the kinds of early warning signs that can be detected by each approach. The table is not complete in terms of covering every possible warning sign but may help in understanding the significance of this division. By using formal assessments and looking for indications as exemplified by the left side in the table, one is unlikely to detect the type of indications mentioned in the right side of the table, unless very much aware of their potential as early warning signs.

What Effect Did Complexity Have?

Complexity clearly gave rise to particular effects. [N4] noted that in a complex project everything is less well known and more interconnected—in particular, reciprocal influences between the many elements [N2]. Such effects make analyzing causality in complex projects much more difficult. [U1] showed the difficulty in perceiving early warning signs arising from difficulty in comprehending the needs of a complex project. One particular lesson that could have provided an early warning sign in [U2] was that dyadic or bilateral contracts are not sufficient for an organizational-

ly complex project. However, [N2] suggested that the advantage in a large complex project is the acceptance and awareness of the environment around the project. This, combined with the availability of resources (competence and capacity) of large, complex projects, helps success even in complex situations.

Why Were Early Warning Signs Not Acted Upon?

A large number of different EWS were detected, but usefulness is only realized if detected early warning signs are acted upon. Various case studies showed early warning signs being detected but not acted upon. In retrospect, it was clear that some things could have been done differently, or some early warning signs were missed, implying a number of lessons. [U1], for example, showed a project that was too large for the governance structure.

A number of projects showed the effects of politics, including:
• A "political" agenda and political pressure to implement some kind of a solution, and then later on overlooking warning signs [U1]
• Some projects may still be given high priority and be fast-tracked to approval

if politically powerful interests stress the strategic need of these as being urgent [A1]
• An early warning sign that perhaps was not detected was the political influences themselves in a highly political domain [U2]
• Changing priorities and pressure to choose certain solutions despite previous decisions by the mother organization and the recommendations of the project team [N5]

Discussion and Conclusions

Looking for Early Warning Signs

In our study, we initially found that some of our key initial assumptions were confirmed: Current project assessment methods are established as a tool for the project owner to be reassured that the decisions about a project are based on a sufficient fundament of facts and analysis. These assessments are generally performed as part of stage-gate procedures and anchored in established governance frameworks. Most governments, corporations, and organizations do have such governance frameworks, formalized or not, on a high level. We also found proof that these assessments are limited is their ability to pick up early warning signs. They have an implicit focus on some issues (e.g., risks, progress, financial development) and thus turn "a blind eye" to other issues. Even when combining many different assessments on different levels and with a carefully fitted combination of focus areas, there might be issues and effects that slip through the formal assessments. What then can be done to improve this situation?

We looked into why established assessment methods fail to pick up early warning signs. The literature tells us that we are not good at seeing through complexity, uncertainty, and interpersonal effects. Our interviews and case studies added some details. Many attempts are reported at learning from previous projects, but these attempts are reportedly not very effective. Reasons indicated included lack of

time to think about the critical issues, lack of time to prepare "lessons learned," reluctance to "air dirty laundry," an overemphasis on the view of projects as unique, and the difficulty of learning from reports with insufficient contextual information. Overemphasis on the view of the project as unique reduces the motivation to even try—"We are so different from other projects that we cannot learn much from them." In the case studies, we find evidence of optimism bias leading people to overlook, or at least not act upon, early warning signs; indications of a lack of an external view (not external enough, not frequent enough), or too much trust placed in experienced people and consequently insufficient owner involvement. We find incidents of believing that assumptions will be stable permanently; we see motivational bias, hiding warning signs; attitudes that hold that "it is not my job" to shape the project and then passively overlook warnings; attitudes suggesting that a project is so urgent that there is no time to dwell on an identified problem ("failure is not an option"); and actors insufficiently tough to tackle conflicts at their roots. Although some of the reasons for failing to pick up early warning signs are technical, the main challenges seem to be found within the minds of individuals. Additional issues include group thinking, blame culture, political pressure, and power effects. These are obviously good reasons to look at the way we assess projects again. What do we need to change in order to improve on identifying early warning signs?

Experience reported in the interviews and case studies showed that the assessment exercises themselves (the process), and not the identified indicators, were most important, because they allowed crucial questions to be raised early. This is the first important conclusion: the exercise is more important than the result, and the timing is decisive. An assessment raises awareness and allows for critical questions and discussions. Doing it early, on a

stage where real options are still available, gives room for the assessments to represent a powerful tool. However, we see a tendency to introduce assessments too late. The arguments used to postpone are generally to wait for more facts, but the point is asking critical questions about needs, objectives, and assumptions before the facts.

The case studies and interviews showed us that dialogue and organizational culture play a key part in detecting early warning signs. This confirms the need for "gut-feeling" approaches that can capture signals not easily covered by more formal approaches. This confirms what Nikander and Eloranta (2001) and Whitty (2010) indicated in their work. This is the key to fixing the shortcomings of any formal assessment, or combinations of such. Where the formal methods are good at identifying EWS in the issues they are designed to look at, the informal "gut-feeling" approaches are the possible way to look for signals without having a specific focus or issue in mind. Of course, this is not an easy task. It cannot be learned by education or trained in courses—it has to rely on the assessor having broad experience and a deep understanding of both objectives and culture.

The literature shows that increasing complexity makes it more difficult to detect and interpret signals. There are clear indications that this is well known in the (public) governance frameworks, most of which are directed primarily toward large, complex projects (such projects are more critical, and they are the ones that have the resources to do thorough assessments). Interviewees similarly indicated that complexity was more important than size (although they can be related). The case studies show that complexity has some particular effects. Issues are less well known, and there are more interconnections (and more reciprocal influences, so it is difficult to deduce interactions from understanding the parts). Causality is less clear. It is difficult to comprehend

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needs and effects. Behavioral complexity makes patterns and positions difficult to understand. Complexity and dynamics in the environment are hard to foresee and respond well to.

Project management practices need to "fit" their context to provide value (Thomas & Mullaly, 2008), and contextual factors are important in defining complexity, so these also influence the appropriate choice of practices (Snowden & Boone, 2007); the interviews and the case studies support this. However, the governance frameworks and their guidelines suggest similar approaches and assessments across sectors and project types. One of the most interesting observations in our material was this mismatch between actual practice and the previous two conclusions. There seems to be a tendency to increase the number and frequency of formal assessments with the complexity of the projects. Our findings indicate that the real need in more complex situations may be more "gut feeling"–based approaches.

The consequence is changing governance and management methodology: by implementing formal assessments, the dependence on "gut feeling" seems to be reduced, but also the ability to use "gut feeling" to detect early warning signs. On the positive side, we find that large, complex projects do have awareness of the surroundings, as well as more time and resources to influence their situation. On the negative side, our interviews and cases indicate that there are important obstacles in interpreting and identifying clear signals in complex situations—which maybe suggests that formal assessments that are usually dominated by analytical approaches may actually be inappropriate (not sufficient) in complex projects. We saw in some cases examples of how analytical approaches had been useful to avoid potential problems, but even more examples of not succeeding to do so. The interviews gave indications that there is a mix of "hard issues" (technical and more

measurable) and "soft issues" (people issues, e.g., attitudes and values, harder to measure) among the early warning signs. In general, the interviewees advised: use an outsider's view, be anchored on a high level in the permanent organization, and look for inconsistencies to detect lack of trust, signs of inappropriate culture, lack of clarity in thought, and misalignment between qualitative and quantitative analysis. They confirmed that "knock-on effects" occur frequently. They recommended solving issues immediately and thoroughly.

What Early Warning Signs to Look For

Which are the most important early warning signs to look for in the different contexts, and why? The guidelines gave us a list of 30 important potential early warning signs—which could have been much longer, given the rich basis of the checklists—but with no indication of relative importance. The list is context-independent, except that the basis on which it is developed came from large, complex projects. We found the expected duality between "hard" and "soft" issues expressed in the early warning signs, naturally "hard" issues being identified typically through formal assessments and "soft" issues being identified through gut feeling–based assessment.

Our interviews can be compared to Meier (2008), who investigated U.S. federal intelligence and defense agencies projects and found EWS manifested by overzealous advocacy; immature technology; lack of corporate technology roadmaps; requirements instability; ineffective acquisition strategy and contractual practices; unrealistic program baselines; inadequate systems engineering; and inexperienced workforce and high turnover. Meier's factors are more specific, while our results are formulated on a higher level; we are looking for the important early warning signs (point to the most severe issues, are most useful, have more effect), Meier for the most frequent ones (that

occur more); our interviewees represents a wider set of project types and organizations in three countries, whereas Meier's sample was one specific type of context in one country. Factors such as leadership and culture are not present in Meier's results, which had a strong focus on contract and technical ("hard") issues. This might be because of the cultural context of Meier's data; our results do not have contextual elements included (with the exception of "location decisions" indicating physical infrastructure). However, context really does matter, and that it is especially important to understand the cultural conditions around and in the project to be able to pick up the earliest warning signs.

Kappelman et al. (2006) gave a good list of early warning signs, and one that explicitly ranks them according to importance; these were for IT projects, but the warning signs seem relevant to most other types of projects as well. Again, a comparison of these warning signs with those from our interviews is shown in Table 5.

Both point out important aspects of documentation, the business case/relevance of solution, leadership issues, and competence in the team. Some aspects in the two columns are related, such as "risks" and "change control," or "quality of information" and "lack of requirement/criteria"; we have location decisions and their consequences, and Kappelman et al. had stakeholders and their involvement and communications. Our interviewees perhaps have an external, project owner focus, and Kappelman et al. had a more internal, project management focus (e.g., we mention governance guidelines and culture; Kappelman et al. mentioned ineffective planning and change control management, etc.).

Table 6 shows a structured summary of all our empirically based early warning signs from interviews and case studies. Formulations with the same or similar meaning are removed, although some occur in more than one phase. We can compare this list to the literature,

Our results from interviews (most important)	Kappelman et al.: IT projects (most important)

Process-related:
  • Quality of information and documentation produced
  • Main risks identified
  • Location decisions and complications from such
  • Relevance of the proposed solution compared with needs
  • Whether guidelines for early phase assessments and "behavior" were followed
  • The need for development of new technology
 	
People-related:
  • Sponsor with unclear expectations and role
  • Leadership issues
  • Culture, whether specific conditions exist that will make cultural aspects a factor
  • Missing competence in the project team
	Process-related:
	  • Lack of documented requirements and/or success criteria
	  • No change control process (change management)
	  • Ineffective schedule planning and/or management
	  • Communication breakdown among stakeholders
	  • Resources assigned to a higher-priority project
	  • No business case for the project
	
	People-related:
	  • Lack of top management support
	  • Weak project manager
	  • No stakeholder involvement and/or participation
	  • Weak commitment of project team
	  • Team members lack requisite knowledge and/or skills
	  • Subject matter experts are overscheduled

Table 5: Comparison of interview results with Kappelman et al. (2006).

although of course our results do not cover all possible early warning signs (e.g., the specific technical and contract-related warning signs in Meier, 2008). First, the division between assessment-based and gut-feeling-based early warning signs is parallel to the division line between authors such as Jaafari (2007) and Oakes (2008), who focused (only) on assessment-based indicators, and researchers such as Nikander and Eloranta (2001) and Whitty (2010), who held "gut feelings" and nonverbal information, individual's feelings, differences in culture, and also miscommunication as main sources of early warning signs. We strongly hold that in order to see through complexity, one will need both kinds of approaches. Second, we have included signs at the time of project setup, in the early stages, and during project execution.

We tend to look at the projects from the owner's perspective and have a strong governance flavor and external focus. This is especially evident in the project setup and early stages columns; the project execution column, on the other hand, has more project management issues. Comparing our tables to the literature reveals that our empirical results have more in common with the early warning signs extracted from guidelines of governance frameworks than other research results. This is especially true for the assessment-based indicators in the first two columns; the more project execution-related results compare quite well to Kappelman et al.'s (2006) results. We have also identified a few early warning signs that we have not found in the cited literature: people in acting positions without authority (may be similar to "weak project manager"), project team overrelying on others to fix problems, team members working too much or too little, contractor unfamiliar with domain, lack of commitment to make decisions, parties making reservations, changes in positions over time, unwillingness to conclude, considering needs as unreal, lack of trust, the way answers are given to critical questions, and continually unfulfilled promises

Why Early Warning Signs Are Not Acted Upon

Early warning signs are possible to identify, as we have seen in several case projects. However, we have found little evidence that project managers have found ways to exploit these to identify and deflect future problems. This leads to the next issue: Why, then, are they not acted upon? Fundamentally, it is hard to do when there is no time to think ahead and question assumptions, so time pressure is one reason. This explains why there is little motivation for spending time extracting and using lessons learned. Another organizational reason for this is the mismatch in incentives between the organization and the individuals. The individuals bring the experience with them to the next project and do not see the need for securing the ability of the organization to learn. Earlier, we also found a number of reasons why early warning signs are overlooked, and many of them are also reasons why identified signals are not acted upon. Among the important ones is the tendency to optimism: the trust in the project's ability to run faster and fix the problems, and it will be fine in the end. A number of projects showed the effects of politics, including a "political" agenda and political pressure to implement a given solution, and powerful interests stressing the strategic need of the solution as being urgent. This indicates that the responsibility to actually make effective actions possible may not lie with the project managers, but with the project owners.

	Project setup	In early stages	Project execution
Assessments	• Sponsor(s) with unclear role • Lack of an implemented governance framework • Poor project definition • Lack of clarity in rationale, goals, and benefits • Poorly developed business plan • Poor definition of scale and what resources are needed • Unclear what assumptions are valid about the project • Lack of relevance of the proposed solution compared with the needs • The need for development of new technology • Main risks not identified	• Lack of a good business case • Deterioration of relations between the participants • Lack of a common definition of roles and responsibility • The project team overrelying on the consultant/contractor's people to "fix it" • Numbers/information missing in documents • Assessments not performed • Documentation not completed • Inappropriate quality of information and documentation produced • Missing competence in the project team • Guidelines for early phase assessments and "behavior" not followed • Disputed major decisions and complications arising from these • Main risks not identified	• People in "acting positions" with no authority to recommend action • Lack of documentation • An excess of "no cost/no time" effects leading to optimism bias • Contractor unfamiliar with domain responsibility • High level of subcontractors' claims and extension of time claims • Plans and reports too late and/or not clear • Contract obligations not fulfilled • Milestones/activity definitions unclear or missing • Missing competence in the project team • Remaining risks not identified
Gut feeling	• Sponsor(s) having unclear expectations • Vague or unclear reasons for undertaking the project (unclear thinking) • Needs considered not real • Inconsistent arguments about agendas • Uneasy comments and body language • The way questions are asked and how answers are given • Specific conditions exist that will make cultural aspects important	• Leadership issues • The way answers are given to critical questions, when the answers are vague • Strained atmosphere • Lack of a culture of openness and good communication between the actors • Confusing or wavering changes in position over time • Uneasy comments and body language • Stating uncertainty, unwillingness to conclude • Parties unwilling to share relevant information • Parties voicing reservations and politically hedging their positions	• Leadership issues • Lack of commitment to make decisions • Frequently changing decisions • Continually unfulfilled promises • Vague answers to critical questions • When people work too much or too little • Uneasy comments and body language • Not showing trust in the project organization

Table 6: Early warning signs extracted from our empirical studies.

Contribution and Further Research

To summarize, our study:
• Has systematically linked stage-gate models, project assessments, and early warning signs; we perhaps now have more elements for a model that may be used to explain and/or detect early warning signs
• Contributes a richer background for claiming that every project is unique and has to be analyzed within its own context to detect early warning signs
• Supports the use, under given circumstances, of some simpler rules of thumb

• Indicates the usefulness of the "hard" indicators in the moderately complex projects
• Indicates the "soft" nature of many early project problems and corresponding warning signs (e.g., political, communication, leadership, culture)
• Shows "gut-feeling" indicators are important, particularly in complex situations and that some can be characterized or systematized; this may serve as an input to improve governance frameworks and guidelines
• Shows the difficulties with organizational culture in identifying such "gut-feeling" indicators

We have also identified some ideas for further research:
• We studied a variety of governance frameworks, but what really happens in practical terms within these arrangements would be a useful study (some of this done by the Concept Research Programme for the Norwegian Ministry of Finance and in the United Kingdom by the Office of Government Commerce and the National Audit Office).
• One consequence of the industry/project-type specific nature of the findings is that there is a need for such specific studies to consider which

early warning signs are the most important in each industry/project type.

- There is a need for more empirical research on the consequence of the degree of complexity in the situation. There are also indications in our case studies that current assessment methods are not good enough when the situation is very complex.

- The problem of identifying and dealing with unknown unknowns remains. More case studies of such situations could provide realistic scenarios to research concerning possible ways of dealing with these.

- We did not make much progress toward identifying the "knock-on effects" before they happen; this is important in answering the question of how to see through the complexity. There is need for more empirical studies or action research.

- These results are for three countries, one Scandinavian and two Anglo-Saxon, and more research is needed in other cultures.

Acknowledgments

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