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Evaluating Sources of Risks in Large Engineering Projects: The Roles of Equivocality and Uncertainty

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Contemporary project risk management literature introduces uncertainty, i.e., the lack of information, as a fundamental basis of project risks. In this study the authors assert that equivocality, i.e., the existence of multiple and conflicting interpretations, can also serve as a basis of risks. With an in-depth empirical investigation of a large complex engineering project the authors identified risk sources having their bases in the situations where uncertainty or equivocality was the predominant attribute. The information processing theory proposes different managerial practices for risk management based on the sources of risks in uncertainty or equivocality.

Keywords: project risk management, complex projects, uncertainty, equivocality, information processing theory, risk sources

Introduction

Managing and evaluating risks is an essential part of project management. Project managers must have some grasp on risks relevant to their projects and the sources of these risks (Chapman & Ward, 2003; Royer 2000). The level of riskiness is especially high in large and international projects that involve a complex temporary network of stakeholders that possess heterogeneous resources, knowledge, and capabilities and have different and often conflicting objectives (Flyvbjerg, Bruzelius, & Rothengatter, 2003; Morris & Hough, 1987; Orr & Scott, 2008; Ruuska, Artto, Aaltonen, & Lehtonen, 2009). Furthermore, the complexities of the socio-political environment and cultural differences, which are inherent in international projects, pose challenges for project planning and hence on risk management (Miller & Lessard, 2001). Consequently, international projects often cannot be realised as planned and unexpected events dominate their lifecycle (Aaltonen,

Kujala, Lehtonen, & Ruuska 2010; Tukiainen, Aaltonen, & Murtonen 2010).

In projects, information processing is needed to reduce both uncertainty and equivocality (Galbraith, 1973). Information processing theory recognises a need for different information processing mechanisms depending on the prevailing circumstances of uncertainty and equivocality (Daft & Lengel, 1986). The sources of organisational uncertainty and equivocality are technology, interdepartmental relationships, and environment. Technology in this context means knowledge, tools, and techniques used to transform inputs into organisational outputs. The second source of uncertainty and equivocality is the need for negotiations across departments. Each department develops its own functional specialisation, time horizon, goals, frame of references and jargon and, therefore, interdepartmental relations are needed to enable transactions across departments. Projects, as open systems, are influenced by their environment. Hence, also the analysability of the project's external environment and the way the organisation approaches its environment (organisational intrusiveness) also determines the need for information processing (Aaltonen et al., 2010; Weick & Daft, 1983).

The literature on risk management has recognised uncertainty, i.e., the lack of information, as a source of risks (Ward & Chapman, 2003). Several scholars have categorised risks based on the source of uncertainties that projects encounter, such as uncertainty about the basis of estimates and uncertainty about fundamental relations between project parties (Krane, Rolstadås, & Olsson, 2010; Miller and Lessard, 2001). However, while the role of uncertainty as a basis of risks is well recognised in the literature of project risk management, limited attention has been paid to the role that equivocality, i.e., the existence of multiple interpretations about situations may play in the risks that projects face during their lifecycle. In particular, complex international networked projects are vulnerable to risks that originate from the multiple and conflicting interpretations of the project participants and about the environment.

The aim of this study is to evaluate the sources of risks in large international engineering projects by adopting the perspective of the information processing theory that maintains that both uncertainty and equivocality contribute to the need of organisations to process information. Hence, it is relevant to take into account both uncertainty and equivocality as the basis of risks. The research question of this study is: What are the roles of equivocality and uncertainty as bases of risk sources in large engineering projects? For the purposes of this study, the authors conducted a single case study of a large and complex infrastructure project that was carried out in an Eastern European country. The end customer executed the project outside its home country with a main contractor that had a different cultural background. The

turnkey contractor was a Northern European company whose two main contractors originated from the home country of the end customer. The focus of the empirical analysis was on the realised risks of the project and on the evaluation of the sources of the identified risks. These sources were divided into those having their basis in uncertainty and those having their basis in equivocality.

Literature Review

In the risk management literature, one of the most common ways to classify risks is to divide them into groups based on common sources or features (Krane et al., 2010). The contemporary project risk management literature sees uncertainty as a basis of risk sources confronted in projects. Ward and Chapman (2003) described risk sources from the uncertainty viewpoint. They identified the types of uncertainties as (1) variability associated with estimates, (2) uncertainty about the basis of estimates, (3) uncertainty about design and logistics, (4) uncertainty about objectives and priorities, and (5) uncertainty about fundamental relations between the project parties. In turn, Miller and Lessard (2001) identified the sources of risks in large international engineering projects and found that risks rise mainly from three categories: market-related risks, completion risks, and institutional risks. The categories are further divided into several risk classes in which the specific risks tend to belong. Market-related risks are divided into demand, financial, and supply risks; completion risks are divided into technical, construction, and operational risks. Institutional risks, the last category, are divided into regulatory, social-acceptability, and sovereign risks. Artto, Martinsuo, and Kujala (2011) divided risks related to projects into four different risk types: pure risks, business risks, financial risks, and area-specific risks. Pure risks include accidents or losses; financial risks are related to the financing and funding of the project. These risks regard such matters as liquidity, operative cash flow, and fluctuating interest rates. Area-specific risks are due to some specific conditions of the area, where the project is executed and are usually caused by the political, legislative, national, cultural, and natural environment of the area. Business risks in the project context mean the miscellaneous group of risks that do not fit into any other risk category but may have an impact on the project, its objectives, or benefits. Business risks include those that may relate to the functionality or usability of the end product and also those that are threats or possibilities during project execution (Artto et al. 2011). In addition to uncertainty, equivocality is recognised to have a role as an attribute of the situations from which risks are noted to have arisen (Pekkinen & Kujala, 2014).

In the information processing literature, uncertainty is understood as a

lack of information and equivocality as ambiguity, the existence of multiple and conflicting interpretations. The literature introduces different information processing mechanisms for these two types of information processing needs (Galbraith, 1974; Daft & Lengel, 1986; Martinez & Jarillo, 1989). From the risk management perspective, recognition of the risk source is important because different information processing mechanisms are needed to manage risks based on their sources. Daft and Lengel (1986) stated that sources of organisational uncertainty and equivocality are technology, interdepartmental relationships, and the environment. Technology in this context means knowledge, tools, and techniques used to transform inputs into organisational outputs. A technology model can be characterised by task variety and task analysability (Perrow, 1967). Task variety is the frequency of unexpected and novel events that occur in the conversion process and task analysability concerns the way individuals respond to the problem. In the case of a task being unanalysable and having high variety, equivocality is the prevailing attribute and, hence, rich information media and informal information processing mechanisms are needed. The second source of uncertainty and equivocality is the need for negotiations across departments. Each department develops its own functional specialisation, time horizon, goals, frame of references, and jargon. The characteristics that influence the need of information processing between departments are strength of interdependence (Allen and Cohen, 1969; Gruber, Ponsgen, & Prakke, 1974) and differentiation (Daft & Lengel, 1984). Low interdependence and differentiation between departments represent a situation of low equivocality and emphasizes the need of formal information processing mechanisms to reduce uncertainty. The third source of equivocality and uncertainty is the interpretation of the external environment. Weick and Daft (1983) discussed the analysability of cause-effect relationships in the external environment as a character determining the need for information processing. The other dimension in the environment model to define the need for information processing is the organisational intrusiveness (passive-active). An active role of the environment toward organisation can be understood as a situation of a hostile, competitive, rapidly changing environment or circumstances when the organisation depends heavily on the environment for resources. Unanalysable cause-effect relationships and active relationships between an organisation and its environment mean high equivocality and require informal media-rich information processing.

Large international engineering projects executed by complex project networks in challenging country environments inherently encounter many unclear events. Clearance referring to the reducing of uncertainty can be achieved by gathering more information about the analysable loosely connected variables and attributes. For unanalysable characteristics with high

interdependence and differentiation, a conclusion to the relevant questions to be answered is needed to reduce equivocality of the situation. Hence, in international and complex project set-ups, both uncertainty and equivocality can be considered as prevailing conditions and potential sources of risks.

Methodology

In prior research on sources of project risks, the focus has been on project set-ups and situations where uncertainty is present. In order to also include equivocality as a basis of the risk sources, a case study research design was employed. By using an in-depth, qualitative research method the authors mapped unexpected events and the realised risks experienced within a selected case project. By elaborating the contextual factors and prevailing circumstances, it was possible to gain a deep understanding of the nature of risk sources (Yin 2002). Additionally, the qualitative method enables a rich examination of the circumstances and conditions in the context where the unexpected events and the realised risks occurred in a way that is not attainable using survey methods. The case project was selected due to its complexity in terms of project participants, project environment, and the range of unexpected events and realised risks. The project was a large green-field engineering project carried out in an Eastern European country and had a monetary value of more than 200 million USD and a lifecycle of over 5 years. The end customer was a Southern European company with permanent operations in the host country, while the turnkey contractor was a Northern European company that used various local subcontractors and two main contractors originating from the home country of the end customer. The two main contractors of the turnkey contractor and the end customer had cultural ties. For the turnkey contractor, the project was a strategically important project in a new market area. The sales phase was fast paced and intensive. In addition, the project environment was challenging due to the unstable political situation and constant changes in regulations. The project network of the case project is illustrated in Figure 1.

For the turnkey contractor, the project was a strategically important project in a new market area. The sales phase was fast paced and intensive. In addition, the project environment was challenging due to the unstable political situation and constant changes in regulations.

The data were collected through 10 interviews, lasting between 50 and 180 minutes. All interviews were recorded and transcribed and conducted with all the relevant key project individuals; interviewees included the project directors, project managers, project team members (e.g., project engineers and controllers), as well as those in charge of risk management in the turnkey company of the project. The research utilised a semi-structured interview approach and all interviews were conducted informally, encour-

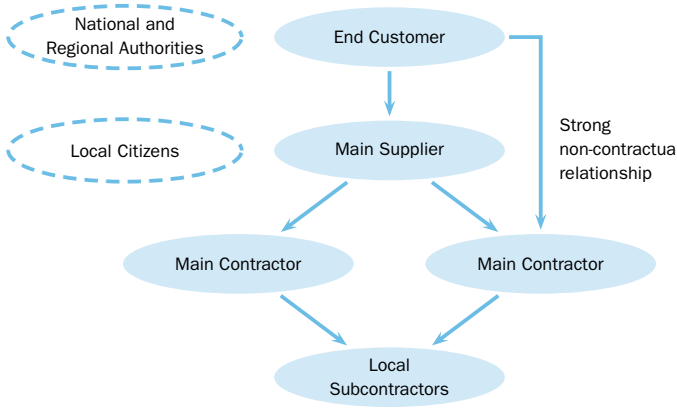

Figure 1 Project Network of the case Project

aging a natural flow of discussion on the unexpected events and risks of the project to gain detailed descriptions of the events and circumstances that led to the events. In addition, an ethnographic interview style was partially used to promote in-depth and lively answers from the interviewees. When analysing the risk sources, authors utilised project-related documentation such as risk analyses, project status reports and project plans as secondary archival data.

The transcribed interview content was carefully analysed to identify relevant risk sources for the exposure of the realised risk events, as well as prevailing circumstances. Risk sources were categorised as those arising from situations where uncertainty, i.e., the absence of information, was a prevailing attribute and those where equivocality, i.e., the existence of multiple and conflicting interpretations about the situation, was a dominant feature. Different risk sources were gathered in an Excel sheet, empirical examples of the different risk sources were identified from the transcribed interviews, and indications of how these risk sources were experienced in the project were listed with citations for each risk.

Empirical Findings

The unexpected and realised risk events delayed the entire project and caused cost overrun to many actors. Although the end customer was occasionally disappointed with the turnkey contractor, the turnkey contractor was able to maintain a good and embedded relationship with the end customer, and the end customer remunerated the turnkey contractor with a new contract. Realised risks were analysed and risk sources were categorised based on the prevailing attributes of the situation. Risk sources were distinguished to those arising from situations where high uncertainty was a

Table 1 Categorised Risk Sources of the Case Project

Uncertainty	Equivocality
High turnover of the project personnel	Cultural differences
Unclear roles of the project participants	Complex network of different actors
Immature inter-organisational relationships between the actors	Unstable country environment
Lack of information about the country environment	

prevailing attribute and to those where equivocality was a dominant feature. High turnover of the project personnel, unclear roles of the project participants, undeveloped inter-organisational relationships between the actors and the lack of information about the country environment were perceived as risk sources that were found to have their bases in situations where uncertainty is the predominant attribute of the contextual factors. In turn, cultural differences, the complex network of different actors, and an unstable country environment were identified as risk sources having their bases in the equivocality of the situations. The categorised risk sources identified in the project are presented in Table 1.

In the case study, four primary risk sources were found to have their bases in the situations where uncertainty (a lack of information) was the dominant characteristic. Three main risk sources with their bases in equivocality (the existence of multiple and conflicting interpretations) were identified. Based on the analysis, the local country environment was identified as being a risk source that related to both uncertainty and equivocality.

A high turnover of project personnel was a distinctive feature of the project. The turnkey contractor changed its main project personnel, including project director and project managers, many times. This was partly caused by the turnkey contractor's own interests and the project participants' own will but was also highly influenced by the pressure from the end customer for real actions to recover the project delay. Also, the main subcontractor changed many of its main project personnel during the project execution phase. This high turnover of project personnel caused many undesirable aspects. The turnkey contractor's second project director told that, when he came to the project after one year of the project start-up, only a few of the original individuals who started the project were there. He also pointed out that project practices were unclear to newcomers and actions were needed to establish and agree on the practices to be followed. The project director explained that as a result of the high turnover the project suffered from a lack of prior knowledge and the project overview was missing. The interviewees noted that unclear roles were a risk source caused by inadequately specified responsibilities in the contract. Consequently, the

contract did not offer dispute resolution, and project participants had to partly renegotiate responsibilities. The experienced project director of the turnkey contractor underlined the importance of specifying roles as follows:

> Specification of the responsibilities is vital. I have seen it in many projects. In the beginning of my career, I prepared contracts by myself and know how it goes. There are many parties, we as turnkey contractor, the customer, and our subcontractor. In the case of dispute you ask, who is responsible? There must be only one responsible party. Then it works.

Furthermore, in the sales phase of the project, the turnkey contractor took strategic action to corner a new market area. This led to a situation where the turnkey contractor did not have a developed business relationship with the customer neither with its own contractors. The pressure to enter a new strategic market area led to a situation where some promises given to the customer in the sales phase of the project were overly optimistic. In turn, the undeveloped relationships between the turnkey contractor and its contractors meant that the turnkey contractor could not anticipate the contractors' responses when facing difficulties, such as when contractors had financial problems and were nearly bankrupt. In other words, the contractors did not consider the establishment of long-term relationships with the turnkey contractor but behaved opportunistically and maximised their benefits of this one-off project, as illustrated with the following quote from the project director:

> We [turnkey contractor] noticed that progress was not as planned and noted that guys were not working. They just did not appear on the site. We found out that the subcontractor wanted more scope. They said: 'Give us more scope and then we will do all that you have given to us.'

The slow and ambiguous permitting process was also one of the main causes of project delay. The turnkey contractor signed the contract with the strategic new customer after a short and intensive sales phase. As a consequence, evaluation of the local environment in relation to the permitting processes and market was not thoroughly performed, and the long amount of time needed to get all the required permissions for construction and operation was not considered. The turnkey contractor's project director stated how they lacked experience in the permitting process and so had difficulties that caused the most severe problems of the project. The lack of knowledge of the local country environment related to the selection of suppliers forced the turnkey contractor to evaluate potential suppliers after the project start-up.

Consequently, the high turnover of project personnel, unclear roles of the project participants, undeveloped inter-organisational relationships between the actors, and the lack of information about the country environment were risk sources that had their bases in uncertainty (a lack of information). The description of the identified risk sources and their implications for the project are listed in Table 2.

Our empirical data analysis revealed that cultural differences, complex project network of different actors, and unstable country environment were risk sources having their bases in situations where equivocality was a prevailing feature of the situations. The turnkey contractor was a Northern European global project-based company executing projects in many continents. The project personnel of the turnkey contractor were used to work in different countries and in different cultures. Regardless of this, the personnel of the turnkey contractor were surprised by the cultural differences between the Northern, Southern, and Eastern European cultures and the embodiments of these differences. A typical example is when the Eastern European company project personnel of the end customer reacted strongly over a delay to the project. After half an hour of yelling, the disappointed representatives of the end customer recognised that this was not the fault of the new project director and with a calmer attitude were able to potentially achieve solutions. In the Southern and Eastern European business cultures, personal relationships are very important. Personal relationships and personal power were seen to exceed even the company boundaries as can be noted from the following citation:

> Personal relationships are very strong. If you have known someone in your past, you are friends forever and you can always ask a favour from your friend. This is valid also in the business relations. In the site, if you run out of some material, you can borrow it from your competitor. These kinds of strong personal relations mean that we [from another culture] have to be very careful about what we say. Tomorrow other companies are aware of what you said.

The Eastern European meeting behaviour also differed from the Northern European approach. It was important for the local contractors that the official protocol of a meeting was strictly followed. In addition to the official agenda and official protocol, unofficial and informal discussions and meetings were held and important project decisions were made in those meetings. In the event decisions were agreed in the official meeting without a pre-agreement, the agreement was verified after the official meeting with informal discussions to involve more personal commitment. The project personnel of the turnkey contractor had to learn how to verify the decisions in the Eastern European business environment where many, often conflicting,

Table 2 Risk Sources, Empirical Examples, and How Risks Were Experienced in the Project When Risk Sources Related to High Uncertainty

Risk source related to high uncertainty	Descriptions of the risk source	Empirical examples	Implications
High turnover of project personnel.	Unclear project practices.	Turnkey contractor and its main contractor changed most of their project personnel by the end of the first year of the project.	Project practices had to be renegotiated between the turnkey contractor and the end customer and between the turnkey contractor and its main contractor.
	Unclear big picture of the project.	The turnkey contractor and its main contractor changed most of the project personnel by the end of the first year of the project.	Past experience and the overview of the project were lost due to the high turnover of project personnel.
Unclear roles of project participants.	Not clearly specified roles.	In the contract responsibility of one task was specified for several actors.	In the case of a dispute, the contract specifications could not be used to solve the problem.
Undeveloped inter-organisational relationships between actors.	Relationship between the turnkey contractor and end customer.	For the turnkey contractor the relationship was new and strategically important.	Turnkey contractor gave non-realistic promises (too tight project schedule) to get the contract with the strategic new customer.
	Relationship between turnkey contractor and main contractor.	Main contractors were selected only for this project.	Main contractors' weak financial situation caused problems for project execution. Main contractors opportunistically maximised their benefits in this project and did not consider long-term relationships with the turnkey contractor.
Lack of information about the country environment.	Permitting process.	Lack of knowledge of the local permitting process.	The turnkey contractor, main contractor, and end customer were not familiar with the permitting process.
	Local suppliers.	Lack of knowledge about the local market.	The turnkey contractor did not have a network of potential qualified material suppliers.

interpretations were present. Despite delays and problems in project execution, the turnkey contractor was able to maintain good relationships with the end customer by showing a strong personal commitment.

The case project was executed by a complex project network of several actors from different countries and cultures. The end customer executed the project outside its home country with a main contractor that had a different cultural background. The turnkey contractor had two main contractors originated from the home country of the end customer. The two main contractors and the end customer had cultural ties. This complexity was one risk source and was detected in several matters. The turnkey contractor and the main contractors had interest asymmetries. The main contractors opportunistically maximised their benefits in this project and did not consider long-term relationships with the turnkey contractor. The main contractors had a close relationship with the end customer and had a similar business culture because they were originally from the same home country. Because of this close relationship, the main contractors released some of the obligations to the end customer despite not having a contractual relationship with the end customer. This by-passing of the contractual counter partner confused the turnkey contractor but also resulted in a release of some obligations. When the main contractors were not happy with the outcome of a negotiation with the turnkey contractor, a separate mutual deal was made between the main contractors and the end customer. In addition, different actors with different business cultures understood the contract differently and interpreted it based on their own cultural premises. For example, in the case project a local contractor did not start the work until receiving an advance payment even though the payment was not stipulated as a precondition for starting the work.

The local inhabitants formed an important actor in the complex project network. Their behaviour was not considered rational when they started to oppose the project. Despite relevant permissions to build the sites, some individuals argued that the construction sites were dangerous; this resulted in halting construction work for further investigations. Although permission was eventually granted again, time was lost and the extra delay impacted the entire project.

Although the local country environment was identified as a risk source with its basis in uncertainty, the authors also found evidence showing that the local environment was a risk source from the equivocality perspective. The permitting process was problematic in many ways. Equivocality was a prevailing feature in the permitting process that was not analysable and was based on stable institutional manners and causality. The process was vague for all the actors, including the local participants. Equivocality relating to the local environment was also perceived in the behaviour of the main

Table 3 Risk Sources, Empirical Examples, and How Risks Were Experienced in the Project When Risk Sources Related to High Equivocality

Risk source related to high equivocality	Description of the risk source	Empirical examples	Implications
Cultural differences.	Eastern and Southern European culture and business culture were not well known to the Northern European project participants of the turnkey contractor.	Managing via personal relationships.	For Eastern and Southern European project participants, personal relationships are important in the business. Strong personal power inside the Eastern and Southern European companies.
		Reacting to conflicts by showing emotions.	The end customer showed its disappointment with strong emotions when the progress of the project was behind schedule.
		Shadow agenda and shadow agreements.	A formal protocol was followed in the meetings but important issues were discussed and agreed informally before or after the formal meetings.

Continued on the next page

contractors. For example, the main contractors initiated a strike to improve their contractual position with the turnkey contractor and to increase the scope of their supply. The turnkey contractor's project manager described this as nonrational and unexpected behaviour. Risk sources, the description of the risk source, and its implications for the project are presented in Table 3.

Based on our analysis, the risk sources were categorised depending on whether uncertainty or equivocality was a dominant attribute of the situation. Four risk sources – (1) high turnover of the project personnel, (2) unclear roles of the project participants, (3) immature inter-organisational relationships between the actors, and (4) the lack of information about the country environment – were perceived as risk sources having their bases in situations where uncertainty is the predominant attribute. On the other hand, three risk sources were found to have their bases in situations where equivocality was the prevailing contextual feature: (1) cultural differences, (2) complex network of different actors, and (3) unstable country environment. In a complex project, contingency factors are manifold, and risk sources can have their bases in both uncertainty and equivocality.

Table 3 *Continued from the previous page*

Complex network of different actors.	Conflicting goals.	The turnkey contractor and its main contractor had interest asymmetries.	The main contractor opportunistically maximised benefits in this project and did not consider long-term relationships with the turnkey contractor.
	Close relationship and similar business cultures between main contractor and end customer.	Tendency to agree issues without contractual relationship.	The main contractor utilised its close relationship with the end customer to maximise its benefits and income by-passing its contractual relationship with the turnkey contractor.
	Local citizens.	Not rational behaviour.	Although the turnkey contractor had building permission, some individuals agitated the public to oppose the project.
	Many actors of different cultures and countries.		Many contractors from different countries and cultures partly brought to the host country based on project managers personal mature business relationships.
	Deviating interpretations of the contract.	Deviating interpretation of contract effectiveness.	Contractors did not start to work before an advance payment was made.
Unstable country environment.	Permitting process.	Lack of stable institutions and causality.	No actors were aware of the different steps of the permitting process and its causality.
	Behaviour of the subcontractor	Main subcontractor's opportunistic behaviour.	Main subcontractor was on strike to get a larger scope.

Discussion

Realised risks of the case project were analysed and risk sources were categorised based on the prevailing features of the situations. A high turnover of project personnel, unclear roles of the project participants, undeveloped inter-organisational relationships between the actors, and a lack of information about the country environment were perceived as risk sources having their bases in situations where uncertainty is the predominant attribute. Cul-

tural differences, complex network of different actors, and unstable country environment were found to be risk sources having their bases in the equivocality of the situations. It was also found that a risk source can have its basis in both uncertainty and equivocality.

In the project risk management literature, uncertainty is defined as the main cause of risks (Ward and Chapman, 2003). Project risk management tools are used to handle risks that have their bases in uncertainties. Furthermore, it seems that the majority of these tools (Project Management Institute, 2008; Association for Project Management, 2006; Chapman & Ward, 2003) are formal ones based on the information processing mechanisms needed to reduce uncertainty (Daft & Lengel, 1986). Hence, current project risk management is based on an assumption that further knowledge concerning the environment and project actors are gained when project execution proceeds and this leads to the project plan being revised. The present study complements the existing literature on project risk management by proposing that not only uncertainty but also equivocality is a relevant factor as a basis of project risk sources.

In large engineering projects, project actors and stakeholders form a complex network. This study highlights the importance of taking into account the different and conflicting interpretations that diverse actors of the project network may have in project risk management processes. The existence of contradictory information and different interpretations to be factors that are valid as risk sources were found, particularly in the context of large international engineering projects (Miller & Lessard, 2001; Floricel & Miller 2001; Atkinson, Crawford, & Ward, 2006).

Although equivocality is not explicitly recognised to have a role as a source of risks, in the current project risk management literature discussion risk sources having an ambiguous nature have been recognised (Morris & Hough, 1987; Flyvbjerg et al., 2003) and different approaches for managing risk have been introduced (Miller & Lessard, 2001; Floricel & Miller, 2001; Thiry, 2002). Miller and Lessard (2001) specified a managerial approach that focuses on turbulence and shaping of risk drivers for risks having a nature of utmost complexity. Based on the information processing theory, informal tools are relevant for situations where equivocality exists (Daft & Lengel, 1986). The present study contributes to the existing project risk management literature by indicating that attributes of risk sources should be considered when selecting risk management tools and that informal tools should be preferred in cases where equivocality is the prevailing attribute of the risk sources.

Managerial Implications

Current project management practices are mainly based on a strategy of preparing a solid and detailed project plan based on available information

at the time of the commencement of a project. Project performance is monitored, and the progress is compared to plans. Should any deviations be identified, the project plan is reviewed and modified. Tools for project plan preparation, monitoring, and re-planning are primarily based on formal information processing methods, such as information systems, reports, and planning activities. In addition, project risk management practices and tools are performed according to the principles of formal information processing practices.

In this study it is shown how informal information processing methods are particularly relevant in complex project networks and circumstances with equivocality and ambiguity as the prevailing features. In this context, informal tools, such as group meetings, integrators, and direct contact communications, can be the most effective and practical tools for project risk management. Face-to-face risk meetings for risk identification and risk response planning are occasions where different, ambiguous, and conflicting interpretations can be discussed and a consensus on relevant issues and questions can be reached. Direct contacts of representatives of different project actors are forums for discussions to reduce equivocality and to get common understanding of contextual situations. These informal processes can be facilitated by integrators who can also be outsiders to the project.

Conclusion

Managing and evaluating risks is essential for project management. Traditionally, uncertainty has been recognised as a source of risks. Information processing theory also recognises equivocality to be an important factor for the need of organisations to process information when ambiguity prevails and multiple and conflicting interpretations exist. Here risks in a large complex engineering project, concentrating particularly on the evaluation of sources of risks were analysed.

The results of this study indicated that sources of risks can be divided into those having their basis in uncertainty and those with their basis in equivocality. A high turnover of project personnel, unclear roles of project participants, undeveloped inter-organisational relationships between actors, and the lack of information about the country environment were perceived risk sources that were found to have their bases in the situations where uncertainty is the predominant attribute. Cultural differences, a complex network of different actors, and an unstable country environment were identified as risk sources having their bases in situation equivocality. The results of this study indicated that a single risk can have its basis in either uncertainty or equivocality or both. Uncertainty is typically taken into account in project management. Nevertheless, equivocality also has an impact on large engineering projects, as some relevant risks have their basis

in situations of multiple and conflicting interpretations rather than a lack of information.

The implications of this study complement the existing literature on project risk management by highlighting how equivocality is a relevant factor in addition to uncertainty. Practitioners and interested academics may find it beneficial to consider the attributes of risk sources in relation to risk management and related tools for information processing. For example, utilising informal tools may be beneficial when equivocality is the prevailing source of risk. The limitations of this study include the analysis of only one large engineering project and the low number of interviews. Future research should include analysing different types of projects in conjunction with risks, equivocality, and uncertainty. The use and effectiveness of different project risk management tools and practices for risks having uncertainty or equivocality as bases of risk sources would also be an interesting line of research. Applying frequency analysis on a larger sample of companies might also strengthen the current understanding of evaluating sources of risks and the roles of equivocality and uncertainty in project context.

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