Doctoral Consortium

A Process For Total Information Risk Management (TIRM) in Asset Intensive Organisations

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1 Introduction

Information has been recognized as a resource of vital importance to all organisations (Eaton and Bawden 1991). Information quality (IQ) has therefore been identified and confirmed in many studies as one of the six dimensions of success for information systems (Delone and McLean 2003; DeLone and McLean 1992) and as an important strategic advantage for today's companies (Redman 1995; Huang, Lee, and Wang 1998). Moreover, information quality is considered as a major challenge regarding information systems in the industry today (Schusell 1997; Firth and Wang 1996; Orr 1998; Lin et al. 2007).

Companies in asset-intensive industries (e.g. transport, manufacturing), are under constant pressure to reduce their operating costs and optimise the utilisation of their physical assets. The effective use of asset information is a key factor for helping them meet their objectives. Studies in asset-intensive industries have shown that 75% of employees are not confident about the quality of their information (Lin et al. 2007).

Many studies have investigated and proven that the quality of information has an impact on organisational performance (Slone 2006; Redman 1998; Fisher and Kingma 2001). Although there is enough evidence available that IQ has a significant impact on organisational success, it is yet unclear how companies can identify and measure the business impact of IQ on asset management in their organisation, which is essential to financially justify any larger IQ improvement activity in front of the board of directors and senior management. In particular, information quality impacts have a probabilistic nature, which is not reflected in any existing approaches. In my PhD, I will therefore investigate the following research question:

RQ: How to effectively manage (i.e. assess and treat) information risks that arise from poor information quality in asset-intensive organisations?

My research is on the crossway between four research disciplines: information quality, management of information systems, (engineering) asset management, and risk management, see Figure 1. The goal of this research project is to provide a practical methodology to assess and treat information risks arising from poor information quality by transferring methods from the risk management to the information quality management discipline.

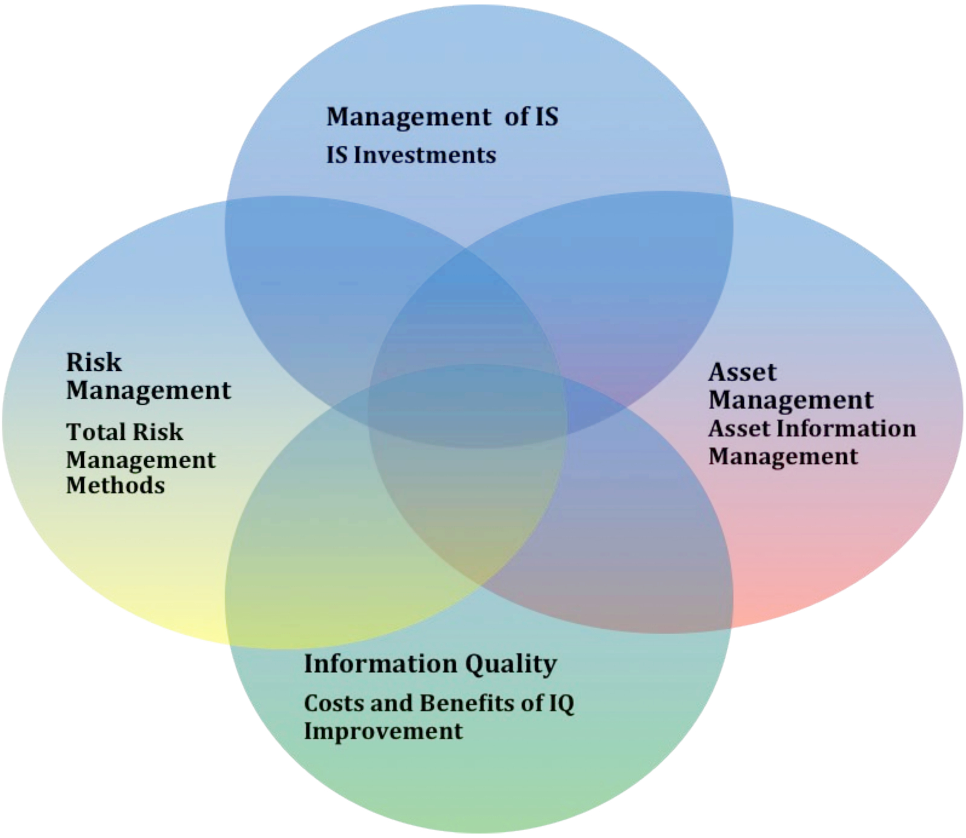

Figure 1: Research Disciplines

2 Research Background

2.1 Information Quality

Information quality is usually defined from a user-perspective as the fitness for use of information (Wang 1998; Wang and Strong 1996), a concept adapted from the quality management literature (Juran 1988). Although "information" is usually defined either as processed data or data with meaning in the information system (IS) discipline and "data" is described as a raw fact (Mingers 2004), the term "information quality" is used synonymously with "data quality" in the literature as it is difficult to differentiate between these two terms (Madnick et al. 2009). The concept of information quality is multi-dimensional - examples of dimensions are accuracy, accessibility, consistency, completeness or timeliness (Wang and Strong 1996). A major point of interest in information quality research is the question how to assess and improve information quality. Many methodologies for assessment and/or improvement of information quality have been proposed focusing on technical and/or economic aspects of information quality (Batini et al. 2009). Empirical data shows that information quality can have a negative impact on organizational success (Slone 2006; Redman 1998; Fisher and Kingma 2001). The most substantial evidence has been collected through experiments indicating that information quality has a significant influence on decision-making, e.g. (W. Jung et al. 2005; O'Reilly III 1982; Ge 2009; Wonjin Jung 2005). Information quality costs and impacts can be classified along different organizational levels (Loshin 2001; Redman 1998), or divided into direct (immediate negative monetary effects) and indirect costs (Eppler and Helfert 2004). General cost categories can be (1) process failure costs (a process does not perform properly), (2) information scrap and rework costs (information quality is improved manually without addressing the root cause), and (3) lost and missed opportunity costs (English 1999).

2.2 Economic Assessment of Information Quality

A handful of approaches have been presented to identify and measure the cost and business impact of information quality in an organization. *COLDQ* (cost-effect of low data-quality), which is an economic framework that summarises the economic impact in a Data Quality Score Card that links an information quality problem with the information chain, the activities in which the information is used, and the impact and cost that is caused (Loshin 2001). *TQdM* (Total Quality data Management) is a complete methodology that contains a process for measuring non-quality information costs (English 1999). *CDQM* (Complete Data Quality Methodology) is a complete methodology for information quality assessment and improvement that also addresses economic issues (Batini and Scannapieco 2006). The methodology is very unspecific; in particular no further explanation is given about how the measurements and calculations could be conducted. *McGilvray's Ten Step Process* offers the most recent contribution in form of eight techniques for business impact assessment of information quality (McGilvray 2008), which range from simple techniques like collecting anecdotes and documenting information usages to more sophisticated ones like creating a subjective prioritization and calculating the costs of low quality information. It is not shown how results of different techniques could be combined. Altogether, current approaches for economic assessment of information quality suffer from major limitations: (1) Information quality impacts are most often of a probabilistic nature, which is not addressed in any of the approaches so far. (2) The interplay of information from human sources and information systems in decision-making is not sufficiently considered, as current approaches focus on information that comes from technical sources only. (3) Although it is sensible to select IQ improvement options based on their expected cost / benefit ratio, the business impact of information quality is not the centre of current information quality management approaches, but rather a side-issue of the proposed methodologies. Altogether, a comprehensive methodology to assess and treat risks arising from IQ in an organisational-wide scale does not exist yet. Such a methodology should be based on the body of knowledge of the information quality and risk management disciplines.

2.3 Risk Management

A process for managing information quality-related risks should take into account the probabilistic nature of impacts, which implies a transfer of concepts from the risk management discipline. Risk is defined by the ISO Guide 73 standard as the "effect of uncertainty on objectives" (International Organization for Standardization 2009a, 9). Risk is therefore connected to a consequence and a likelihood. It can be measured, depending on its nature, using either a statistical approach that uses historical data or a subjective probability approach in an informed decision (Merna and Al-Thani 2008). Moreover, risk is context-dependent as it reshapes when the system changes (Barrese and Scordis 2003; Miller 1992). Risk management has academically evolved over time from analysing one event, its probability and consequence to the analysis of multiple events, which led to research about management structures for risk management (Kumar 2010). Many different processes have been suggested in the literature for risk management, e.g. (Williams, Smith, and Young 1995; Hopkin 2010; Barrese and Scordis 2003; Merna and Al-Thani 2008). Typically a risk management process contains the steps (Kumar 2010): (1) identification of risks, (2) assessment/measurement of risks, (3) evaluation, choice and implementation of risk mitigation options, (4) monitoring of risk mitigation.

2.4 The Context: Engineering Asset Management

The process is developed in the context of asset management organisations in asset-intensive industries like manufacturing, transport, energy, utility, etc. The British Standard Institute defines asset management in their specification PAS 55-1 as "systematic and coordinated activities and practices through which an organization optimally manages its assets, and their associated performance, risks and expenditures over their lifecycle for the purpose of achieving its organizational strategic plan" (British Standards Institution 2004, V). Asset management considers the whole lifecycle of an asset, from acquisition to disposal. The asset lifecycle can be divided into different phases, which are in a fundamental form: Acquire, Deploy, Operate, Maintain and Retire (Ouertani, Parlikad, and McFarlane 2008).

In a nation-wide survey, Lin et al. find that a majority of data owners, collectors, custodians, and consumers in asset management companies recognize that information quality plays an important role for business success and that they are not satisfied with the quality of their information (Lin et al. 2007).

3 Research Methodology

The goal of this research is to build and evaluate a practical process for effectively managing information risks in an asset management organisation. We follow, therefore, a process-based approach, developed by (K. W. Platts 1993), which has already been proven to be both rigorous and effective for designing management processes in various contexts, e.g. the design of performance measurement systems (Neely et al. 2000). Following Platt's process-based approach, the process development occurred in four research phases, as illustrated in Figure 2. Overall, our research is, thus, based on a qualitative interpretative approach. Case studies are an appropriate research method to address the given research problem as they can provide an in depth analysis of a high number of variables of interest in a real-life setting and are, in particular, very suitable for addressing "how" questions (Yin 2008). To ensure practicality of the process, we use action research in our main in-depth case studies in research phases 2 to 4. In action research, the researcher takes both the role of an academic researcher and the role of a consultant within one or more projects, which gives a much better access to reality than in all other research methods (Gummesson 2000). Next, we describe each research phase in detail.

The first phase was the initial design of the process on the basis of a review of the existing IQ and risk management literature and interviews with managers (operational, strategic and IT) and consultants (management and IT) about information risks in different asset management industries. In the second research phase, the process has been tested and refined by application of the process in a semiconductor manufacturer, a steel manufacturer and an electrical utility company.

All three studies have been executed by the first author of this paper (the developer of the TIRM process) during which he spent one week at the actual company sites to facilitate the workshops. Before and after the site visits, phone interviews and meetings were conducted. As part of the research project, we have developed a spreadsheet-based tool that guides industrial users through the different steps of the process, which has been used in the workshops and for the analysis of the results. After each workshop, a feedback discussion took place to analyse how the process can be improved and refined. In the third research phase, the process has been applied in an additional in-depth case study in a company that manufactures electrical and electronic industrial components. This time, the process has been, however, applied by an independent facilitator, who is a last year master student in business engineering. An independent facilitator is used to show that the feasibility of the process is not dependent on the knowledge and skills of the researcher. The process has been evaluated using feedback discussions and questionnaires using the criteria feasibility, usability, and utility and a number of sub-criteria.

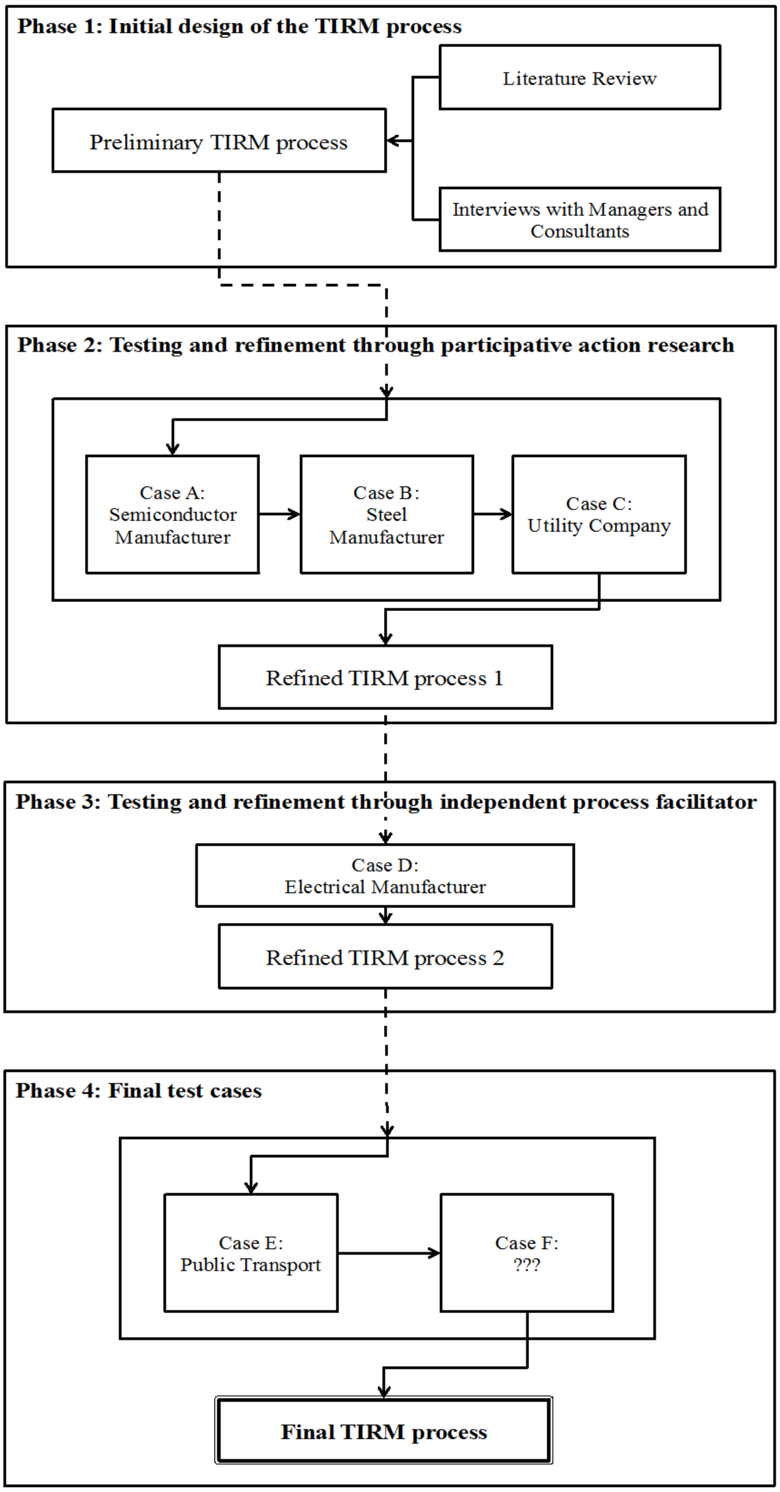

Figure 2: Process Development

4 Current State of Research

The doctoral project is currently in the middle of the third research phase, see Figure 2. At the moment, a master student is executing the process for Total Information Risk Management (TIRM) in a manufacturing company in the role of an independent facilitator. Case studies from previous research phases have been already completed, which includes the exploratory interviews and three in-depth action research case studies, i.e. a semiconductor manufacturer, a steel manufacturer and an utility company.

Based on the review of the literature and the industrial interviews, we found that a process for managing information risks in an organisation should aim at:

- Systematically assessing and mitigating information risks in an organisational-wide scope.
- Considering information provided by all sources, e.g. IT, documents and humans, external and internal information etc.
- Being based on a widely accepted risk management standard to assure its acceptance in the industry and that it incorporates current risk management best practices.
- Building on concepts and assessment and improvement techniques from the IQ discipline.

An internationally widely recognised standard, ISO 31000, is used as a basis for the TIRM process. ISO 31000 provides general guidelines and a terminology for risk management (International Organization for Standardization 2009b). In particular, it consists of a risk management framework and a risk management process. The TIRM process can be used within the ISO 31000 framework and follows the ISO 31000 risk management process steps, but also refines each process step to adjust the process specifically for managing information risks, as illustrated in Figure 3. There are five general process stages: communication and consultation, establish the context, information risk assessment, information risk treatment and monitoring and review of the process. We will now briefly summarise the current versions of the TIRM process steps.

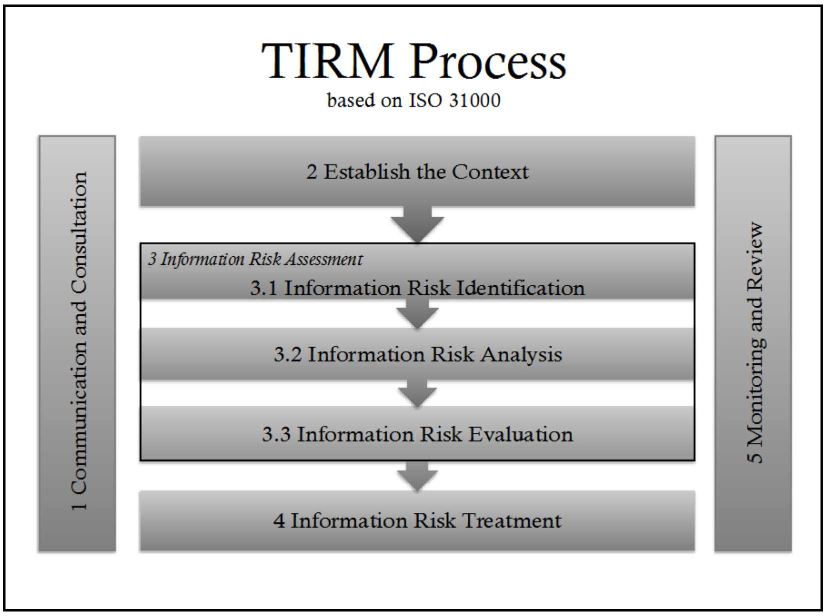

Figure 3: TIRM process

Process Stage 1: Communication and Consultation

Throughout the TIRM process, communication and consultation should take place with all relevant stakeholders. As the TIRM process crosses functional boundaries, it is key that senior management is committed to the information risk management initiative. It is also important that the IT management and risk management executives are aware and supportive of the initiative. The goals and benefits of the information risk management programme need to be clearly communicated to all people involved in or affected by the TIRM process to gain active support.

Process Stage 2: Establish the Context

Before information risks can be assessed and treated, the organisational context has to be established in discussions with (a) senior general management, (b) IT and knowledge management, (c) risk management (d) and the relevant functional managers. The external and internal context of the organisation need to be established along with the context of the TIRM process and, if available, risk criteria used in the organisation. In particular, it is important to understand the current information management capabilities in the organisation to be able to analyse information risks. IQ management capabilities can be assessed using one of the many existing IQ management maturity assessment models (Caballero et al. 2008; Baskarada 2008), which have their roots in Crosby's maturity model introduced in the quality management area (Crosby 1979). The relationship between information management capabilities and information risks is discussed in (Borek et al. 2011) in further detail.

Process Stage 3: Information Risk Assessment

Information risk assessment consists of three sub-steps: First, potential information risks are identified by uncovering existing (and future) IQ problems in an organisation, then, the likelihood and impact of possible consequences of these IQ problems are analysed, and finally, information risks are evaluated.

Process Step 3.1: Information Risk Identification

First, information risks need to be identified in a defined scope. This requires understanding what information is required for a given process or activity and where IQ problems do appear. IQ can be assessed using existing IQ assessment methodologies, see (Batini et al. 2009) for a good overview. The output is a set of IQ problems for each process or activity.

Process Step 3.2: Information Risk Analysis

Second, the risk of each IQ problem needs to be analysed. Risk analysis "involves consideration of the causes and sources of risk, their positive and negative consequences, and the likelihood that those consequences can occur" (International Organization for Standardization 2009a, 18). This can be done qualitatively using significance scales like "low", "medium, "high", or quantitatively by taking estimates; an overview of risk analysis techniques is given in (International Organization for Standardization 2009b).

Process Step 3.3: Information Risk Evaluation

Third, a thorough risk evaluation is required, taking the wider context of information risk management into account, e.g. the level of other information risks and their inter-relationships. In particular, it needs to be decided if an information risk should be treated, by comparing the level of risk with risk criteria from step 2, and the priorities of different treatments implementations have to be determined (International Organization for Standardization 2009a).

Process Stage 4: Information Risk Treatment

ISO 31000 describes risk treatment as “selecting one or more options for modifying risks, and implementing those options” (International Organization for Standardization 2009a, 18). Information risk treatment is a cycle, which starts with the assessment of the treatment and evaluating if the remaining information risk is not tolerable, in which case a new information risk treatment is created and assessed.

According to ISO 31000, risk treatment can be further subdivided into two phases: “selecting of risk treatment options” and “preparing and implementing risk treatment plans” (International Organization for Standardization 2009a, 20). This subdivision is, however, still on a very high level of abstraction and can be detailed for treating information risks by using existing IQ improvement activities from the literature. We have summarised existing IQ improvement approaches in a Ten Step approach for improving information quality in (Borek, Woodall, and Parlikad 2011).

Process Stage 5: Monitoring and Review

The risk management process has to be monitored and reviewed, either ad-hoc or periodically, to assure that controls are effectively working, to collect additional information for improving risk assessment, analyse experiences made and to identify changes in the internal and external context and new risks. The results from the monitoring and review step should be recorded and reported. Furthermore, they provide an input for the review of the risk management framework.

5 Plans for Completion

Based on the results, feedback, experiences and insights from research phase 3, we will once more refine the TIRM process, especially to make it easier to be used by independent facilitators. We will then proceed to research phase 4, in which we will have at least two final test case studies. The research will be finished by autumn 2012.

References

Barrese, J., and N. Scordis. 2003. "Corporate Risk Management." *Review of Business* 24 (3): 26–30.

Baskarada, S. 2008. IQM-CMM: Information Quality Management Capability Maturity Model. PhD Thesis, University of South Australia, August.

Batini, C., C. Cappiello, C. Francalanci, and A. Maurino. 2009. "Methodologies for data quality assessment and improvement." *ACM Computing Surveys (CSUR)* 41 (3): 16.

Batini, C., and M. Scannapieco. 2006. *Data quality: Concepts, methodologies and techniques*. Springer-Verlag New York Inc.

Borek, A., M. Helfert, M. Ge, and A.K. Parlikad. 2011. An information oriented framework for relating IS/IT resources and business value. In *Proceedings of the International Conference on Enterprise Information Systems (ICEIS)*. Beijing, China.

Borek, A., P. Woodall, and A.K. Parlikad. 2011. A Risk Management Approach to Improving Information Quality for Operational and Strategic Management. In *Proceedings of the 18th EUROMA Conference: Exploring Interfaces*. Cambridge, UK.

British Standards Institution. 2004. *Asset Management: PAS 55-1: Infrastructure Assets*. BSI Standards, April.

Caballero, I., A. Caro, C. Calero, and M. Piattini. 2008. "IQM3: Information Quality Management Maturity Model." *Journal of Universal Computer Science* 14 (22): 3658–3685.

Crosby, P. B. 1979. *Quality is free*. McGraw-Hill New York.

DeLone, W. H, and E. R McLean. 1992. "Information systems success: the quest for the dependent variable." *Information systems research* 3 (1): 60–95.

Delone, W. H, and E. R McLean. 2003. "The DeLone and McLean model of information systems success: A ten-year update." *Journal of Management Information Systems* 19 (4): 9–30.

Eaton, J. J., and D. Bawden. 1991. "What kind of resource is information?" *International Journal of Information Management* 11 (2) (June): 156-165. doi:10.1016/0268-4012(91)90006-X.

English, L. P. 1999. *Improving data warehouse and business information quality: methods for reducing costs and increasing profits*. John Wiley & Sons.

Eppler, M., and M. Helfert. 2004. A classification and analysis of data quality costs. In *Proceedings of the 9th International Conference on Information Quality (ICIQ-04)*, 311–325.

Firth, C. P., and R. Y. Wang. 1996. "Data quality systems: Evaluation and implementation." *Cambridge Market Intelligence Ltd., London*.

Fisher, C. W, and B. R Kingma. 2001. "Criticality of data quality as exemplified in two disasters." *Information & Management* 39 (2): 109–116.

Ge, M. 2009. Information quality assessment and effects on inventory decision-making. Doctoral Thesis, Dublin, Ireland: Dublin City University, September.

Gummesson, E. 2000. *Qualitative methods in management research*. Sage Publications, Inc.

Hopkin, Paul. 2010. *Fundamentals of Risk Management: Understanding Evaluating and Implementing Effective Risk Management*. Kogan page.

Huang, K. T, Y. W Lee, and R. Y Wang. 1998. *Quality information and knowledge*. Prentice Hall PTR Upper Saddle River, NJ, USA.

International Organization for Standardization. 2009a. ISO Guide 73:2009 - Risk management -- Vocabulary. http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=44651.

———. 2009b. ISO 31000:2009 Risk Management – Principles and Guidelines on Implementation. http://www.iso.org/iso/catalogue_detail?csnumber=43170.

———. 2009c. ISO/IEC 31010:2009 - Risk management -- Risk assessment techniques. http://www.iso.org/iso/catalogue_detail?csnumber=43170.

Jung, W., L. Olfman, T. Ryan, and Y. T Park. 2005. "An Experimental Study of the Effects of Representational Data Quality on Decision Performance." *AMCIS 2005 Proceedings*: 298.

Jung, Wonjin. 2005. An experimental study of the effects of contextual and representational data quality on decision performance. Doctoral Thesis, Claremont, CA, USA: Claremont Graduate School.

Juran, J.M. 1988. *Quality Control Handbook*. 4th ed. McGraw-Hill Inc.,US, September.

Kumar, M. 2010. Risk Management Practices In Global Manufacturing Investment. Doctoral Thesis, Cambridge, UK: University of Cambridge, June.

Lin, S., J. Gao, A. Koronios, and V. Chanana. 2007. "Developing a data quality framework for asset management in engineering organisations." *International Journal of Information Quality* 1 (1): 100–126.

Loshin, D. 2001. *Enterprise knowledge management: The data quality approach*. Morgan Kaufmann.

Madnick, S. E, R. Y Wang, Y. W Lee, and H. Zhu. 2009. "Overview and Framework for Data and Information Quality Research." *Journal of Data and Information Quality (JDIQ)* 1 (1): 1–22.

McGilvray, D. 2008. *Executing Data Quality Projects: Ten Steps to Quality Data and Trusted Information*. Morgan Kaufmann, August 22.

Merna, Tony, and Faisal F. Al-Thani. 2008. *Corporate risk management*. John Wiley & Sons.

Miller, K. D. 1992. "A framework for integrated risk management in international business." *Journal of international business studies* 23 (2): 311–331.

Mingers, J. 2004. "Realising information systems: critical realism as an underpinning philosophy for information systems." *Information and Organization* 14 (2) (April): 87-103. doi:10.1016/j.infoandorg.2003.06.001.

Neely, A., J. Mills, K. Platts, H. Richards, M. Gregory, M. Bourne, and M. Kennerley. 2000. "Performance measurement system design: developing and testing a process-based approach." *International Journal of Operations and Production Management* 20 (9/10): 1119–1145.

Orr, K. 1998. "Data quality and systems theory." *Communications of the ACM* 41 (2): 66-71.

Ouertani, M. Z, A. K Parlikad, and D. McFarlane. 2008. "Towards an approach to select an asset information management strategy." *International Journal of Computer Science and Applications* 5 (3b): 25–44.

O'Reilly III, C. A. 1982. "Variations in decision makers' use of information sources: The impact of quality and accessibility of information." *Academy of Management Journal* 25 (4): 756–771.

Platts, K. W. 1993. “A process approach to researching manufacturing strategy.” *International Journal of Operations and Production Management* 13: 4–4.

Redman, T.C. 1995. “Improve data quality for competitive advantage.” *Sloan Management Review* 36: 99–99.

———. 1998. “The impact of poor data quality on the typical enterprise.” *Communications of the ACM* 41 (2): 79-82. doi:10.1145/269012.269025.

Schusell, G. 1997. “Data Quality the Top problem.” *DW for Data Warehousing Management*, *Digital Consulting Institute (DCI)* (October): S5.

Slone, J. P. 2006. Information quality strategy: An empirical investigation of the relationship between information quality improvements and organizational outcomes. Doctoral Thesis, Minneapolis, MN, USA: Capella University, October.

Wang, R. Y. 1998. “A product perspective on total data quality management.” *Communications of the ACM* 41 (2): 58-65.

Wang, R. Y, and D. M Strong. 1996. “Beyond accuracy: What data quality means to data consumers.” *Journal of management information systems* 12 (4): 33.

Williams, C.Arthur, Michael Smith, and Peter Young. 1995. *Risk Management and Insurance*. 7th ed. McGraw-Hill Publishing Co., March.

Yin, Dr. Robert K. 2008. *Case Study Research: Design and Methods*. Fourth Edition. Sage Publications, Inc.