Knowledge Management Applied to Enterprise Risk Management

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Thesis Summary

Risk and knowledge are two concepts and components of business management which have so far been studied almost independently. This is especially true where risk management (RM) is conceived mainly in financial terms, as for example, in the financial institutions sector. Financial institutions are affected by internal and external changes with the consequent accommodation to new business models, new regulations and new global competition that includes new big players. These changes induce financial institutions to develop different methodologies for managing risk, such as the enterprise risk management (ERM) approach, in order to adopt a holistic view of risk management and, consequently, to deal with different types of risk, levels of risk appetite, and policies in risk management. However, the methodologies for analysing risk do not explicitly include knowledge management (KM).

This research examines the potential relationships between KM and two RM concepts: perceived quality of risk control and perceived value of ERM. To fulfill the objective of identifying how KM concepts can have a positive influence on some RM concepts, a literature review of KM and its processes and RM and its processes was performed. From this literature review eight hypotheses were analysed using a classification into people, process and technology variables.

The data for this research was gathered from a survey applied to risk management employees in financial institutions and 121 answers were analysed. The analysis of the data was based on multivariate techniques, more specifically stepwise regression analysis. The results showed that the perceived quality of risk control is significantly associated with the variables: perceived quality of risk knowledge sharing, perceived quality of communication among people, web channel functionality, and risk management information system functionality. However, the relationships of the KM variables to the perceived value of ERM are not identified because of the low performance of the models describing these relationships.

The analysis reveals important insights into the potential KM support to RM such as: the better adoption of KM people and technology actions, the better the perceived quality of risk control. Equally, the results suggest that the quality of risk control and the benefits of ERM follow different patterns given that there is no correlation between both concepts and the distinct influence of the KM variables in each concept. The ERM scenario is different from that of risk control because ERM, as an answer to RM failures and adaptation to new regulation in financial institutions, has led organizations to adopt new processes, technologies, and governance models. Thus, the search for factors influencing the perceived value of ERM implementation needs additional analysis because what is improved in RM processes individually is not having the same effect on the perceived value of ERM. Based on these model results and the literature review the basis of the ERKMAS (Enterprise Risk Knowledge Management System) is presented.

***Keywords**: Knowledge Management, Enterprise Risk Management, Financial Institutions, Information Systems, Knowledge Sharing, Knowledge Management Systems, Risk Control*

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List of Abbreviations

CRM: Customer Relationship Management
COSO: Committee of Sponsoring Organisations of the Treadway Commission
CWC: Organisational Capacity for Work Coordination
ERKMAS: Enterprise Risk Knowledge Management System
ERM: Enterprise Risk Management
ERMIS: Enterprise Risk Management Information System
HR: Human Resources
IIS: Perceived Quality of People Interactions in Risk Management Information Systems Design
ISI: Perceived Value of Information Systems Integration
KM: Knowledge Management
MISF: Risk Management Information System Functionality
NCCP: Perceived Quality of Network Capacity for Connecting People
PERM: Perceived Value of Enterprise Risk Knowledge Management
PQC: Perceived Quality of Communication
QRC: Perceived Quality of Risk Control
QRC: Perceived Quality of Risk Control
QRKS: Perceived Quality of Risk Knowledge Sharing
RM: Risk Management
RMIS: Risk Management Information System
SOX: Sarbanes Oxley Act
VAR: Value at Risk
WCF: Web Channel Functionality

1. Chapter One Introduction

The financial crisis in recent years has created many questions about the performance of financial institutions when adverse events appear. There are doubts about the capacity of the organisations to perform properly the three knowledge components of the management of risk: use of models, use of technology and leverage on people. Regarding these points there are different approaches. On the one hand, academics, such as Professor Tiffano interviewed in Champion's article (2009), pointed out the need to learn and reflect on the economic environment: "Many of the elements of the crisis were being talked about long before it happened." However, Professor Simons expressed the need to think about incentives: "you need motivation in the form of performance pressure, and the financial markets supplied this in spades."

In the same article (Champion, 2009), Professor Simons identified a new component of risk-taking behavior based on the shareholder value that is: "the belief that a particular behavior is economically and morally justifiable." Furthermore, Dr. Mikes in this article indicated the need to review what models can do and what they cannot do: "Models are not decision makers; people are." Taleb et al. (2009) identified the issues with the standard deviation approach for risk analysis. However, managing organisations under risk need not only to learn how to deal with bad times, as Professor Kaplan said (Champion, 2009), but they are also required to understand how to manage opportunities and take into consideration the things that put the organisation at risk.

On the other hand practitioners and analysts have identified various elements to understand the financial crisis. For example, The Economist (2010) presented some statements that indicate issues in gathering and developing a proper knowledge or use of it in risk management problems, such us: "Models increased risk exposure instead of limiting it." As well, the issue of using assumptions and models in a less adequate way to aggregate risk: "Each CDO (Collateralised debt obligations) is a unique mix of assets, but the assumptions about future defaults and mortgage rates were not closely tailored to that mix, nor did they factor in the tendency of assets to move together in a crisis."

Organisations in risk management are using different metrics and analysing the outcomes that the metrics produce in order to support the decision making process. However, using metrics requires more understanding about assumptions and limitations for good application. One of the metrics is the VAR (Value at Risk), the most popular and widely used metric. However, there are weaknesses in this metric, as there are in other metrics, but the point is to use them in two ways: acknowledging their limitations and modelling constraints, and putting various metrics together in order to see the whole picture of the risk map. Regarding this, The Economist (2010) wrote: “So chief executives would be foolish to rely solely, or even primarily, on VAR to manage risk.” The point here is that VAR metric is a good tool when there is liquid security, short periods or under normality behavior of the market, but not under other market conditions or attributes that are in place when some of the derivatives are designed and put in the market.

From the technology point of view, The Economist (2010 and 2009) described the reality in financial institutions, which have invested more than US$ 500 billion globally in technology, as the low capacity to integrate risk analysis. “A report by bank supervisors last October pointed to poor risk “aggregation”: many large banks simply do not have the systems to present an up-to-date picture of their firm-wide links to borrowers and trading partners.” Furthermore, “This fragmented IT landscape made it exceedingly difficult to track a bank’s overall risk exposure before and during the crisis.”

Modeling and technology are not the only improvements to make, but also people need more support as The Economist (2010) pointed out: “Often the problem is not complex finance but people who practise it....because of their love of puzzles, quants lean towards technically brilliant rather than sensible solutions and tend to over-engineer.” People in risk management are not only involved in modelling or quantitative work, there are other various roles and responsibilities that need understanding and support people in order to be performed properly.

Therefore, the aim of this research is to contribute to the RM and KM literature by identifying the relationships between the variables describing the KM processes, in particular knowledge sharing, and the RM management variables: perceived quality of risk control and the perceived value of the ERM implementation. The study is developed two parts: First, analysing the KM variables that have influence in the risk control process, and second, analysing the KM variables that have influence in the perceived value of ERM implementation. The answer to the relationships identification might have a direct effect on financial institutions by allowing them to deal with the problems and crises that they have had, the lessons to learn, the changes in business models, the new regulations and the competition of big players around the world with different levels of risk appetite.

In this research ERM has been identified as risk management (RM) for the whole organisation (See Section 2.2.5) because of RM being the discipline and ERM the integral view of RM. The two terms may be thought of as RM being silo oriented while ERM is a holistic and integral view of RM.

1.1. The concept of financial institution

In this research, a financial institution is considered as a combination of services to answer financial needs of people and companies. Zabihollah (2001) describes what a financial institution is today, saying: “Traditionally financial services provided by banks, insurance companies and mutual funds have been somewhat separate....Consolidation, convergence and competition have transformed the financial services industry from traditional organisations such as banks, brokers, insurance companies mutual funds, and securities providers to asset management companies such as bank holding companies and financial holding companies.” From this description of financial institutions there are some points that summarize the meaning of financial institutions in this research (Abell,1980; Siklos, 2001):

- Financial institutions provide answers to customer functions, such as:
    - Banking, saving, borrowing
    - Investment, advice, support, managing surplus cash and assets management
    - Insurance

    - Global services through cash management and international trade services
    - Capital markets through portfolio and risk consulting services

- Financial organisations support different customer groups. The main groups that financial institutions attend are: personal (individual and families), commercial and corporate.

- Financial organisations amalgamate various technologies depending on the customer group and the customer function. For instance, personal banking can have ATMs and retail offices while corporate can have account managers and tailored products.

A consequence of these different levels of services, customers and technology used is that the information, knowledge, and risk management (RM) practices can require different attributes at each level of the business definition to support the financial services. Besides, risk management is a fundamental task in financial institutions, and some of the risk management questions in financial services are related to (Oldfield and Santomero, 1997) the search for the maximization of the expected profits, which are exposed to potential variability which can transform them into losses.

Financial institutions have a wide risk exposure that is created through a wider offer, which includes more products and services than in the past. This wide risk exposure created doubts about the integral view of risk, the capacity for preventing the potential losses, and the adoption and learning from the experience. In order to get solutions and support for the financial institutions' challenges, some work has been done in regulation. This has, at the same time, created new compliance actions within financial institutions to respond to the regulation which has not included concepts associated with knowledge management or a formal and systematic use of knowledge to improve the performance of the organisation (Wiig 1997; Beckman 1997 and see Section 2.3.2 for details).

The main framework of regulation in RM is the Basel II agreement and it has been complemented by SOX (Sarbanes Oxley), COSO and others. The general regulation framework of Basel II (2004) Capital Accord was developed with several implications for RM practice and for the development of the capacity for managing customer information, transactions information and the risks of operation.

There are three pillars in the Basel II accord. The first is related to minimum capital requirements; the second is associated with supervision of risk profiles; and the third is related to market discipline. The text of the document does not include a reference related to the use of intangible assets of the RM organisation. Additionally, the emphasis of operational risk, which represents a high risk exposure in the financial system, is on data, measurement, reporting and assessment. Additionally, there is no mention of the value of technology in risk management (See Section 2.3.6), just as there is no mention of required practices and strategies to improve the interaction between people and technology in order to reduce potential errors, to be prepared for human solutions when there are system failures or contingencies that affect the work flow and organisation's results.

Moreover, financial institutions have been organised to deal with different risks; the organisation has been designed by groups that manage the actions required to control risk according to market, operations, strategy and credit (See Sections 2.2.3 and 2.2.4). Different teams are involved and perform risk evaluation, quantification, and reporting. Reports consolidate information according to the internal policies and in agreement with regulators. The capacity of the RM organisation to perform its actions is based on the risk management analyst and on the access to resources for using data and producing what the organisation needs for risk control.

Financial institutions have developed various strategies to deal with risk because risk is a factor influencing the organisation's results. However, according to Doherty (2000) in reference to the issue of the effects that risk can have in the expected shareholder income: "Moreover, we need to understand these disruptive effects of risk because appropriate risk management strategies can be formed effectively only if we understand the precise effects of risks." In addition, Doherty (2000) states that the main point is the creation of value in the risk management practice. This is represented by avoiding losses in earnings, reducing the cost of possible losses, or, in general, developing a good practice of hedging and insurance, changing leverage, compensation structures, and so on. None of the strategies from Doherty (2000) or from regulations indicate that managing what people know can be a resource that provides value.

1.2. Knowledge and Risk in Financial Institutions

The organisation and the risk management strategies can be complemented if the following is taken into consideration: Financial institutions are information and knowledge organisations (Fourie and Shilawa, 2004). Risk is one of the business issues to deal with in a financial institution and to manage risk "is frequently not a problem of a lack of information, but rather a lack of knowledge with which to interpret its meaning" (Marshall et al., 1996).

Knowledge reduces uncertainty (Nonaka, 1991) and therefore, knowledge reduces risk (Dickinson, 2001). Furthermore, risk management practices could seek to improve the capacity to generate knowledge and manage it in order to reduce uncertainty. A better understanding of the factors and actions affecting the organisation's risk exposure could be a means to support strategy and its results. However, it is not clear how knowledge is organised and provides support to financial institutions in order to deal with uncertainty and risk.

In addition to the understanding of the value of knowledge as a means to reduce risk, every time that a new risk is identified, new knowledge is required (Shaw, 2005). Risk identification and risk control implies actions such as: modelling the economic effects, or describing the risk characteristics. These actions produce new knowledge and increase the organisation's capacity. In particular, people might, in the interaction with different groups, share knowledge in a financial institution based on their own experiences in order to support the decision-making process. From a management perspective, this means for financial institution management to take into consideration the fact that there are groups of people from multiple disciplines with different knowledge and experiences working together. Thus, financial institutions need to understand this diversity of the interactions and knowledge in order to achieve organisational goals.

During the last century many financial crises have occurred and the analysis of their causes has left a trace in RM. Brealey and Meyers (1996) referred to the 1987 crash as a case to study where the causes have to be identified. They presented different views about these causes and included some lessons to learn: markets do not have memory, meaning, it is not possible to search continuously for an extraordinary benefit. However, the question remains: how much risk knowledge has been improved and how has the experience been learned and used? In 2008 and 2009, reflections about the crises have been in place and the learning process has to improve, and as Taleb et al. (2009) point out: "Remember that the biggest risk lies with us: we overestimate our abilities and underestimate what can go wrong."

RM processes in financial institutions need to include in their continuous improvement process the lessons learned under different circumstances of the financial market (Sawyer, 2008). However, even though Dickinson (2001) introduced knowledge as a factor to reduce risk, there is not a clear identification of the means to improve knowledge sharing. Particularly, to share that knowledge that is in documents or codified results, or to share the knowledge that is in the minds of the employees (Alavi and Leidner, 2001).

The experience and learning that has supported peoples' capacity for performing the operation and the way that employees' capacity has been used in the organisation needs to be understood. Factors such as growth, communication and information infrastructure can be analysed as drivers to understand influence in losses, as some examples of the financial institutions indicate:

- Reduced risk control process in expansion: growth affected the operations at American Express. Expansion ran faster than the growth of capacity and the knowledge support was minimal (Simons, 1999). Some factors were fully analysed, such as: value attributed to information costs, regulation costs, and hidden costs. Possibly the work coordination, technology and communication capacity were affected because of the expansion. The explanation of the issues was related to limitations due to technology failure, technology under exploited and brain drain.
- Lack of communication among groups and culture: The Bankers Trust expansion

reduced the quality of the product presentation to the clients. The reason was cultural pressure. There was a lack of information flow and the products were not well understood. The culture of avoiding bad news reduced the possibility of finding solutions to errors (Simons, 1999). This related to communication issues and lack of capacity to interact with different stakeholders.

- Reduced risk management system functionality and controls: Barings Bank's failure is related to the lack of creation of early warning systems and their relationship to a work environment of rewards and recognition. A short term performance view and internal competition contributed to the bad results (Simons, 1999). Similarly, a lack of communication presenting business values in an understandable way in which people could embrace reduced the company capabilities.

  Possibly, the identification of off-limits actions was unclear (Simons, 1999) and the search of a solution of independent and sliced, by risk areas of risk management data (McKibben, 2004) appears not enough. The search for the development of solutions to control risk exposure and data structures that support a shared problem solving process is needed. Equally, there lacked a review of the need of new technology for data and information management, and the modelling process (Shaw, 2005). This is then associated with people and technology interrelationships and the way to share experiences as well as to have the means for a proper people connection.

The above points open a search for identifying factors that go beyond production and operation procedures in order to manage risk; factors that affect different groups and business units such as knowledge and its use. In particular, it is necessary to identify points that provide guides to organise RM when different groups of risk management areas are working together and that support risk analysis and risk actions across the organisation. The interaction of risk areas requires sharing knowledge in order to solve problems and the actions in control, such as observation of policies across the organisation, which then involves a variety of workers, processes, and technology.

Therefore, these preceding points show the need to do research in the identification and understanding of the variables of the KM processes and their influence on the perceived quality of risk control and the perceived value of ERM implementation. In order to achieve a better level of understanding and management of the risk knowledge, it is possible to use what Von Krogh et al. (2000) identify as a guide to this need for knowledge and learning capacity in RM: “beliefs, commitments, and actions cannot be captured and represented in the same manner as information.” This search for the understanding of the KM and RM variable relationships led to the definition of four specific objectives.

1.3. Specific objectives

To achieve the aim of this research four specific objectives were defined. First, to identify the knowledge and risk management constructs and their related items to use as a basis for research in the field. Second, to identify and put together existing work in each discipline where there are commonalities in application to financial institutions. Third, to seek the KM variables that can influence the perceived quality of risk control and the perceived value of ERM implementation. In a general sense, as Alavi and Leidner (2001) expressed, there is a need to search for attributes affecting the KM processes implementation. The research identifies that part of the complexity of the ERM implementation that is attempting to coordinate RM actions by risk areas or across the organisation.

The fourth objective is, to identify the bases for supporting KM in RM through a knowledge management system (KMS) design. The KMS proposition is based on what Lehaney et al. (2004) presented through the understanding of the components of a KMS, the value provided by IT and the value added of risk knowledge sharing. The research observes that the ERM frameworks do not include the concept of KM or KMS as disciplines to support the ERM, even though implementation and actions of ERM process are people based and the accumulated risk experience is an asset of any RM practice. Furthermore, the research takes into consideration that the KMS for RM needs to support KM as a discipline that can contribute positively (Marshall et al., 1996; Daniell, 2000;

Shaw, 2005) to the RM practice with regard to data and information management, risk knowledge sharing, analysis consolidation and reporting.

The research uses and is based on the data coming directly, through a survey, from the employees of the risk management office in the financial institutions. Equally, this research uses the diverse literatures of financial institutions, Risk Management (RM and ERM) and KM in order to develop eight hypotheses; each one formulated as *a* and *b.* Hypotheses *a* refer to the relationship between KM variables and perceived quality of risk control. Hypotheses *b* refer to the relationship between KM variables and the perceived quality of ERM implementation. The concept of risk management that has been included in the framework of this study is identified with the variation of expected results conditional on previous knowledge.

Throughout this thesis, the terms construct and variable are used as synonyms to mean the property, image or abstract idea built for the research purpose (Cooper and Schindler 2006). The term attribute is the characteristic or quality that an existing system, means, concept or process has.

1.4. Summary

This research is seeking relationships between variables that describe KM processes and the perceived quality of risk control and the perceived value of ERM implementation. This means this study contributes to the understanding of knowledge development of risk management employees in their practice of RM through: identifying the KM variables that influence the perceived quality of risk control and the perceived value of ERM implementation,

The relationship identification between KM and RM is through a review of the items to use for the variable construction. In order to achieve identification of variables and items a framework has been developed, which includes the aspects of knowledge management, risk management and bases of information systems, such as the IT value for the organisation. The relationship identification and the review of the literature provide the bases for the design of a knowledge management system that supports RM processes and develops the capacity to work with multiple groups and different knowledge. In this research, this system will be called ERKMAS (Enterprise Risk Knowledge Management System).

This thesis has been structured as follows: Chapter two includes the theoretical background where the conceptual bases of RM, ERM and KM are discussed. Chapter three presents the research model and hypotheses, which includes all the bases for the hypothesis formulation and the description of the research model. Chapter four describes the research methodology and the means used for gathering data and getting results. Chapter five presents the findings and hypothesis testing results. Chapter six discusses and shows the implications of the analysis of the results. Finally, chapter seven presents the conclusions, limitations and possible new research directions for future work.

2. Chapter Two Theoretical background

In this chapter there is a review of the concepts from the RM and KM disciplines. The purpose is to introduce the concepts and to align the meaning with the aim of the research. These concepts are introduced in independent sections: Organisation theory, Risk, Risk Management, Risk Processes, risk control, Enterprise Risk Management (ERM), Risk Management Information Systems (RMIS), Knowledge, Knowledge Management (KM), Knowledge Management Processes, Knowledge Management System (KMS) and IT value, KM in financial institutions, and the combination of RM and KM in financial institutions. The literature shows that the analysis of the KM application to RM is scarce, particularly when related to ERM and risk control. There are many different articles with regard to each discipline independently, but rarely work that connects the two disciplines.

The theoretical review (See Figure 2-1 Flow of the theoretical review) is for each discipline, organisation theory, RM and KM, and this starts at the basis of the risk concept and goes up to the Enterprise Risk Management System concept, and from the knowledge concept up to the KMS definition. It looks for a link between the concepts and the empirical evidence of the possible relationships already discovered. This review provides a base to identify the main points of analysis in order to design an Enterprise Risk Knowledge Management System (ERKMAS). Particularly, sections 2.4, 2.5, 2.6 present the literature review where RM and KM have been shown with some common points and experiences.

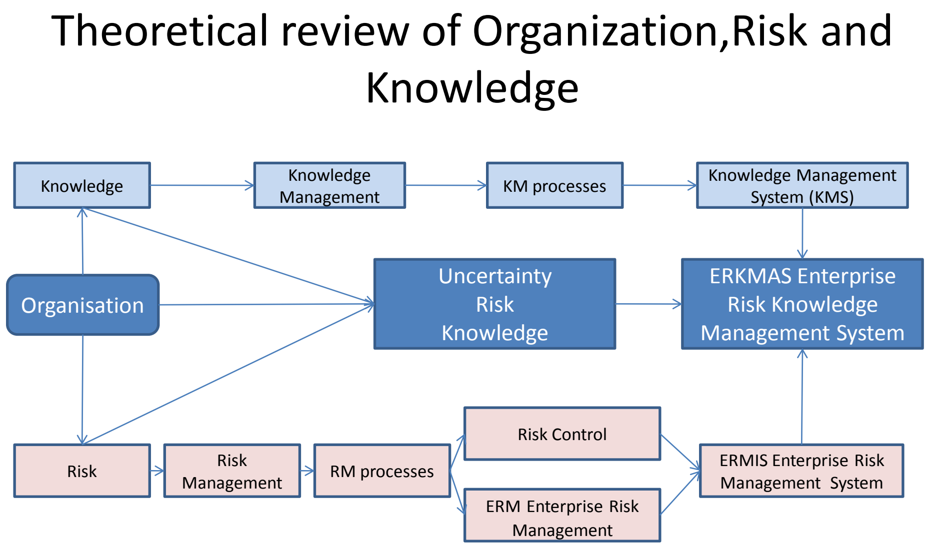

Figure 2-1 Flow of the theoretical review

2.1. Organisation Theory

The concepts behind this research are based on organisation and system theory. In this section two topics are presented: components of the organisation and organisation design. Both bring to the research foundations of variables and items that are relevant when a financial firm is analysed, which will be used in the search for KM and RM relationships. Organisation theory provides the bases of understanding the organisation design and components of the organisation, particularly their identification within a financial institution where the human factor is the basis of production and service. Risk and knowledge in the organisation of financial institutions are part of the operation where risk might appear from the lack of interaction among people involved in decisions, lack of knowledge to deal with transactions or lack of knowledge to create solutions for customers.

Galbraith (1973) pointed out "[t]he greater the uncertainty of the task, the greater the amount of information that has to be processed between decision makers during its execution." This thought identifies that the complexity of the organisation influences the execution, operation and performance of the organisation itself. Risk and knowledge are affected by the combination of activities, the multiplicity of organisation components and the information and knowledge processes. Galbraith (1973) stated that there are some strategies that in a complex organisation, such as a financial institution, are possible to follow in order to manage information: strategies to reduce the amount of information and strategies to increase the capacity to process more information. He indicated that the strategies to reduce the need of information are related to “creation of slack of resources” and “creation of self-contained tasks.” The strategies for handling more information are related to “investment in vertical information systems” and “creation of lateral relations.”

These organisational points put in the context of knowledge management are summarized in the following observation “[m]anagers have found ways to monitor and control well-understood production processes, but there are no proven methods that managers can use in knowledge management.” (Bhatt 2002) He continues “What kind of knowledge is shared and how knowledge will be shared are determined by professionals, not by the management.” Additionally, Chen and Edgington (2005) pointed out, “The manager of an organization has the opportunity and responsibility to strategically align knowledge workers’ assignments to tasks or KC(Knowledge creation) processes.” Thus the organisational volume of information and knowledge will affect the use of those resources but at the same time people involved in the organisation’s processes will play a key role in reducing uncertainty and supporting risk processes.

These previous points put in terms of Andersen’s view (2008) of organisation development “We find a positive relationship between total risk management and corporate performance and observe higher performance relationships among firms investing in innovation and firms operating in knowledge-intensive industries where firm-specific investments are particularly important.” indicates the need to connect organisation theory with knowledge and risk management.

2.1.1. Components of the organisation

According to the theory, organisations possess four main components for their creation: consciously coordinated work, social entities, identifiable boundaries and goals (Robbins, 1990). These components are identified in various ways. For example, Etzioni (1964) defined organisations as: “... social units (or human groupings) deliberately constructed and reconstructed to seek specific goals,” whereas Daft (1992) described them as:

“...social entities that are goal-directed, deliberately structured activity systems with an identifiable boundary.”

The analysis of organisation theory in this research provides value because the organisation definitions bring the clarity of considering the human component of the organisation as a means for a firm to achieve the expected results. The conversion of knowledge into actions is profoundly embedded in a financial institution where the products are based on the knowledge and experience in the identification of service offer. Syklos (2001) pointed out “Thus, we can speak of the banking firm’s output as a set of services. Such a set of services can be termed intermediation which can be thought of as facilitating the transformation of liabilities...into assets.”

These definitions have several points in common. They refer to people who share objectives and goals they wish to achieve and note that it requires an effort to be more efficient, effective and competent in order to keep some structure and coordination. These common concepts encompass the meaning of the organisation used in this research and refer to the entity where KM and RM are acting. In brief, the components of the organisation concept are: a group of people, or social entity, with a coordinated work that follows guidelines, means, methods and design in order to achieve goals.

Financial institutions have multiple products and services that satisfy various market segments and adapt technology to the blend of products and markets. This variety of solutions for customers indicates the need to adapt financial institutions and their business processes to a new requirement of organisational design where information, knowledge and risk must be aligned. This requirement of design is the basis of managing risk knowledge for the customer functions, technology and customer segments that the organisations support. In particular, in this research there is an emphasis on risk, knowledge and the capacity that people have to exchange knowledge and develop work oriented to managing risk.

2.1.2. Organisation design

In the search for the KM and RM relationships organisation design (Stanford, 2007) is required in order to define how organisations operate. One of the points of organisation design is control (Burton and Obel, 1995). Control refers mainly to the process of observing how the business processes are performing in order to convert the resources into the outcomes that the organisation wants to achieve. Another point is the work coordination. Given the need to support a multidisciplinary and interdepartmental work in an organisation, as Burton and Obel (1995) state, “basically, organisations are formed to achieve a set of goals. For cost efficiency the work in the organisation may be divided into a number of separate tasks. To obtain common goals the activities must be coordinated.” In particular control is a set of activities that in the RM setting are performed in order to improve the RM practice and to implement adequately the policies of the financial institution.

Additionally, Morgan (1997) complements the idea of organisational design by saying, “the ability to read and understand what is happening in one’s organisation is a key managerial competence.” Morgan (1997) advises that the way to understand and to put into practice the organisational concepts is through the use of the competing “metaphors” or images of the organisation concept. However, in organisational designs and human actions it is necessary to differentiate what is possible in order to pass from the theory to practice and as a means to solve organisational problems. This differentiation between theory and practice is presented by Clegg (2003) indicating that: “... theory and practice are qualitatively different. Theory is often equated with thinking, abstractness, explanation, and dissection into parts. Practice, by contrast, is equated with doing, concreteness, understanding, know-how and wholes.”

The purpose in the organisation moving from theory to actions is presented by Tsoukas and Knudsen (2003) and indicates that knowledge is converted into actions through the implementation of what is called the Action Cycle in an organisation: diagnosis, invention, production and evaluation. This Action Cycle goes from discovering a problem to evaluating the production of the solution (Argyris, 2003). Additionally, Alavi and Leidner

(2001) consider organisations as people interactions, environment and knowledge systems, and introduces knowledge management processes as part of the organisation design. Thus, organisation design will be understood in this study as the “outcome of shaping and aligning all the components of an enterprise towards the achievement of an agreed mission” (Stanford, 2007).

In the context of this research, an organisation can be affected by different factors but it has to continue in operation. Bolman and Deal (2003) took into consideration the organisational components, the complexity of articulation and the need to stay properly productive in order to survive and compete; “an environment filled with complexity, surprise, deception, and ambiguity makes it hard to extract lessons for future actions. Yet an increasingly turbulent, rapidly shifting environment requires contemporary organisations to learn better and faster just to survive.”

Regarding the identification of the characteristics of financial institutions, organisation theory provides not only a view of the offer that they have but also how the business processes are designed in order to create that offer. The business processes are associated with the changes that have modified their organisational designs and are adopted to follow different strategies. These strategies can introduce more complexity and more risk exposure to the financial institution, particularly when adopting a universal banking practice. There are several examples in the global market that combine the scope of activities and geographical scope to define their business (Canals, 1997).

The search for potential relationships between KM and RM variables is mainly represented in what Mintzberg (1979) proposed as five mechanisms to explain how organisations coordinate work: mutual adjustments, direct supervision, standardization of work processes, standardization of work outputs and standardization of worker skills. These mechanisms involve knowledge management related concepts: The mutual adjustment is through informal communication (See Sections 2.3.1;2.3.4;3.6;3.7 relating to tacit knowledge and knowledge sharing concepts), Equally regarding the concepts of standardization of work processes, outputs and skills Mintzberg (1979) pointed out “sometimes neither the work nor the its outputs can be standardized...Skills (and knowledge) are standardized when the kind of training required to perform the work is specified... so standardization of skills achieves indirectly what standardization of work processes or of work outputs does directly: it controls and coordinates the work. ” In this research Mintzberg’s points open the possibility of investigating how the concepts of communication, work coordination, standardization can affect the organisation, in particular, the RM organisation.

Thus, possibly the learning experience and the consolidation of knowledge use in different areas can influence positively the organisational performance of the current financial institution and prepare the organisation to deal with risks that a higher business complexity may have. This complexity that appears in financial institutions indicates that the concepts of work coordination and people interactions are fundamental to analysis, and at the same time, are part of a systems design. According to Alavi and Leidner (2001), organisations are “social collectives” and “knowledge systems”. Furthermore, to complement the previous points, Kankanhalli et al. (2005) introduces two concepts that will be used later in this research (Section 3.3). First, they point out that social exchanges are based on expectations of future return even though the return is not clearly defined. Second, they note that human relationships promote knowledge exchange when there is trust, norms and identification.

In summary, the above points show that understanding organisations in general leads to the conclusion that in a financial organisation, people coordination, interaction, strategies, and knowledge converted into actions can help the financial institution to deal with the causes of risk that come from the exposure of changes and uncertainty as parts of the organisation’s life. Similarly, knowledge appears as a possible organisational component of development because there is a need to learn and improve the organisational capacity and capabilities for keeping and improving their competences.

This section introduced two main points about organisations. One is the review of components of organisations as bases for the formulation of the variables used in this research. The other is the concept of organisation design that provides guidance for understanding how organisations operate. The next section is dedicated to RM concepts including what RM is. It starts from the risk concept that is the core of RM and reviews RM itself, as well as the processes and the risk management information system. There is an explanation of the differences between RM and ERM that provides an understanding of why this research uses two different RM concepts as dependent variables.

2.2. Risk Management Concepts

In this section different concepts related to risks in the organisation are explained in order to define and to identify the RM basis. The concepts included are: risk, risk management, risk management processes, risk control, ERM, and risk management information system (RMIS).

2.2.1. Risk

Risk is a concept with many different definitions and in some cases, the definition is adapted to the specific risk context or risk type. For instance, the Concise Oxford Dictionary (2008) defines risk as a "hazard, a chance of bad consequences, loss or exposure mischance." From scholars and practitioners such as McNeil et al. (2005), risk is "any event or action that may adversely affect an organisation's ability to achieve its objective and execute its strategies." Adding to this definition the quantitative component of risk, McNeil et al. (2005) say risk is also "the quantifiable likelihood of loss or less-than-expected returns."

From the analysis of operations research and the decision making theory, risk is related to randomness and uncertainty. From different kinds of events, one can differentiate multiple kinds of risks affecting a decision. For example, Eppens et al. (1998) identify risk under the decision perspective and state that decisions under risk are those where it is possible to estimate the probability of the several states of nature that the decision maker has to deal with.

The risk review from March and Shapira (1987) provides insights for the understanding of the risk concept. These authors presented a comparison between the risk concept from the decision theory and the concept that the managers held The difference starts from a managerial focus on risk as potential organisational losses and not on the organisational positive results or variance view of the outcomes; equally, managers concentrate more on the value of the loss than on the probability of the events with the observation that the attitude is that managers are not strongly oriented to measure the risk but to perceive it.

Regarding risk attitudes, March and Shapira (1987) presented that manager's risk attitudes and the way of dealing with risk is associated with this statement "They feel that a manager who fails to take risks should not be in the business of managing." And the authors conclude "Managers look for alternatives that can be managed to meet targets, rather than assess or accept risks." The point with this attitude and risk view is the influence on the support and implementation RM processes because the identification of capacity to control results and to design incentives that lead risk attitudes or choices.

As a complement of the risk definition and the attitudes to risk McNamara and Bromiley (1999) studied the specific case of a bank where the assessed risk should contribute to the expected return indicating that risk refers to "the likelihood of default by the borrower." In this article the presentation includes the need of considering measures on the lending process as a means to understand the judgemental decisions and the links among business processes in the bank. The authors conclude that the managerial definitions of risk and return require a strong "effort to understand and to manage" the risk-adjusted measures that the evaluation of organisations performance require. Indication risk where KM has involvement: operational, financial and innovation level. In section 2.3.6 the value of IT in RM is presented and in particular the observation of the risk concept for Tanriverdi and Ruefi (2004) represented by the chance of losses and magnitude of losses.

These definitions have some components associated with the probability distribution of events that can occur, and the negative effect that those events can produce. In a financial institution, there are different events and risks, such as property or life contingencies and negative changes in returns, currency exchange rates, etc. The probability law that a risk follows differentiates risk from uncertainty, where nothing is known; neither the probability, nor the event characteristics of occurrence.

Risks have been studied and analysed independently in financial institutions. Given the nature of the financial institutions, where a wide exposure can be affected by many environmental factors and from the wide spectrum of financial service activities, there are different kinds of risk that are involved in several actions and decisions in a financial organisation structure. Classification of risks can be indicated depending on the area where the risk analysis is performed. For example, Ong (2006), Van Greuning and Brajovic (2003) and Crouhy et al. (2001) present a classification of risks mainly referring to financial institutions and related to market risk and business risk, such as an operational risk. Market risk and Credit risk have been studied more deeply than operational risk, which has been studied in depth by few authors, such as Panjer (2006). Other risks, non financials, are classified as event risks, such as political risk, and these are shown by Harms (2000). A summary (See Figure 2-2) of the kind of risks is as follows:

- Financial: credit, currency, market, capital, etc.
- Business: legal, regulatory, country, etc.
- Operational: fraud, damage, information, products, etc.
- Event: political, contagion, etc.

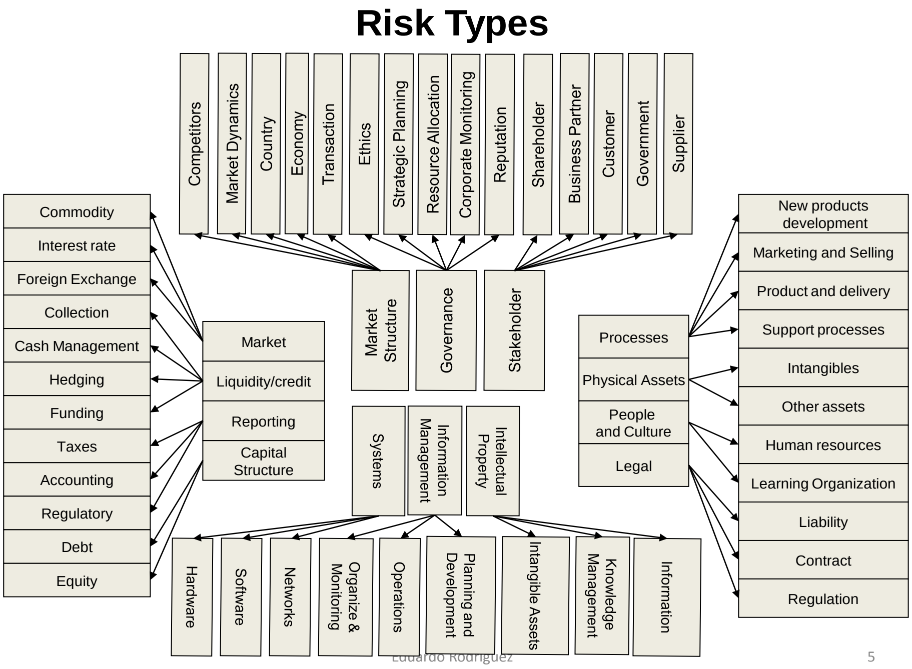

Figure 2-2 Kinds of risks in a financial institution

Finally, risk classification is equally applicable to risks in society, and not only for business purposes such as Bischoff (2008) presents which indicates several risks affecting the current society such as health care, community risks and global risks. Each classification can involve probability laws that describe each type of risk that affect the financial institution and society.

2.2.2. Risk Management

From the previous section, risk implies some kind of clear understanding of the way it is classified and in the way that it is studied and controlled. With this perspective, risk management (RM) appears in the context of the organisations. According to Spedding and Rose (2008) risk management can be defined in general as ”The process of identifying, measuring and assessing risk and developing strategies to manage them. Strategies include: transferring the risk to another party; avoiding the risk; reducing the negative effect of the risk; and accepting some or all of the consequences of a particular risk.”

In particular, for financial institutions, RM is “the overall process that a financial institution follows to define a business strategy, to identify the risks to which it is exposed, to quantify those risks and to understand and control the nature of the risks it faces” (Cumming and Hirtle, 2001). Using RM terminology, and with regard to this research, it is important to differentiate RM from risk measurement that only “entails the quantification of risk exposures” (Cumming and Hirtle, 2001). This is a process in RM. The differentiation makes sense because the risk management outcome encompasses the development of the capacity of risk measurement, and in this research, the interest is the review of RM processes that include other factors such as people and technology interaction to measure and to control risk.

Additionally, risk management is considered important in the strategic management process (Meulbroek, 2002; Sharman, 2002; Liebenberg and Hoyt, 2003; Banham, 2004). The importance is in having the capacity to create value from the analysis of risk (Brown, 2001; Froot and Scharfstein, 1994; Banham, 2004) in order to develop a competitive advantage (Galloway and Funston, 2000). In particular, given the nature of the financial institutions, RM has been adopted as a core competency (Buehler et al., 2008a), and the learning, risk analysis and solutions are part of the day-to-day business. However, as a result of the exposure to more risks and the losses in previous years, a doubt has been introduced about the RM practice. This doubt has resulted in a general regulation framework of the Basel II (2004) Capital Accord, which has several implications in RM and IT decisions.

The main points or pillars considered in this regulation are capital allocation, separation of the operation and credit risk, and the alignment of regulatory and economical capital. Additionally, a new review of the framework is expected to take into consideration the 2008-2009 crisis that could have some roots in the lack of regulation and the lack of synchronization of risk management actions to manage the diverse risk exposure. This lack of synchronization appears through the offer of investment products that made assumptions on the underlying assets that could not be assumed or reached by other products.

Moreover, regulation is a very important factor for business model definitions. The Basel II agreement (2004) established the RM role in financial institutions. The RM processes have to be designed and the next section introduces the bases of the RM processes as they currently are within financial institutions.

2.2.3. Risk Management processes

Buehler et al. (2008a) point out that RM has a mandate: “executives in all companies can incorporate risk into their strategic decision making.” RM processes have been evolving in the emphasis that the organisation has on some of them, such as in the case of the hedging process (Froot et al., 1994) or risk measurement, or innovation in products (Buehler et al., 2008a). The main reflection considers the RM as a process itself, as was explained in the previous section, and identifies that: “transferring risk does not mean eliminating risk.” (Buehler et al., 2008a) There are actions in different processes that involve people and technology to be performed. In 1996, Berstein wrote about the “The New Religion of Risk Management” and pointed out that: “Our lives teem with numbers, but numbers are only tools and have no soul.” This means, in this section, that RM professionals have been searching for meaning through RM processes; they have been looking to them from an independent risk optic to an enterprise view and trying to connect other organisational components such as governance, strategy and operations. Therefore, Lam (2000) presented as RM processes: governance, line management, portfolio management, risk transfer, risk analysis, data technology resources and shareholder management.

However, Brown (2001) introduced a different view of the processes, such as risk identification, measurement, monitoring, control and application. Sharman (2002) additionally included in the description of processes some other management aspects and summarized the processes as: strategy design, structure design, measuring and monitoring, portfolio analysis and optimization in order to protect, release and create value. Table 2-1 presents different approaches in describing the risk management processes. There are some expressions related to the concept of risk control that are common to all the presented authors, such as compliance, monitoring, and reporting. All authors indicate risk assessment, evaluation, and identification as processes that have to be performed in order to establish the potential losses that can be caused by an adverse event. Table 2-1 shows, as part of the RM process, the need for risk communication, support for management and escalation actions to manage different events. This is illustrated in Figure 2-3 of the practice at the Royal Bank of Canada.

Figure 2-3 Royal Bank of Canada RM Governance (Source Annual Report 2009)

This research adopts Brown's (2001) approach given the clear identification of the processes that are part of RM actions. Brown's (2001) simplified view of RM is expressed as follows: "A corporate risk policy facilitates a four-step process: identify the major risks faced by the company, and then create an organised approach to measure, monitor and control those risks." This is in agreement with Basel II where the three pillars (See Chapter 1) require actions to measure, organise data and reports, and support the decision-making process.

Risk Management Processes	References
• Governance • Line Management • Portfolio Management • Risk transfer • Risk analysis • Data technology resources • Shareholder Management	Lam (2000)
• Risk Identification • Risk Measure • Risk Monitoring • Risk Control • Risk Application	Brown 2001
• Strategy design • Structure design • Portfolio analysis and optimization • Measuring and monitoring	Sharman 2002
• Analyse Risk • Risk Strategy design • Implementing Risk Strategy • Monitor Risk Strategy	Bowling and Rieger 2005
The review is given by layers where activities of identification, assessment, reporting, planning, and negotiation are performed. The layers are • Comply jurisdiction layer • Strategy layer • Deployment layer • Operation Layer • Events layer	Abrams et al. 2007
• Objective Setting • Event identification • Risk Assessment • Risk response • Control Activities • Information and Communication • Monitoring	COSO 2004
Description of the CRO and ERM team activities: • Risk identification • Risk Assessment • Advising solutions for dealing with risks • Reporting • Management support	Liebenberg and Hoyt 2003
Based on best practices identify some experiences following the steps: • Establish risk framework • Identify risk events • Assess risks • Plan risk response strategy • Monitor and control risk	Francis and Paladino 2008
• Differentiate the financial and operational risks • Classify and prioritize strategic and manageable risks • Model the risks • Assess the impact of risk on key performance indicators • Manage ERM change (Leadership, Communication, Involvement, Measurement)	Rao and Marie 2007
• Risk identification • Risk analysis • Risk Planning • Risk tracking • risk control • Communication	Williams, Walker and Dorofee 1997

Table 2-1 Risk Management Processes

Equally, Brown's (2001) approach identifies the difference between actions of risk measurement and risk control. This means that in this research, the potential relationships to the KM processes is a review of risk control and the enterprise view, which not only concentrates on risk measurement, but also on other actions beyond quantitative skills that can require specific knowledge capabilities. Therefore, the interest of this research is to follow the RM processes as Brown (2001) describes:

- Risk identification: This process refers to the group of actions developed in the organisation to classify and map risks that can affect the organisation in their current and expected business conditions.

- Risk measurement: Quantification and assessment of risk are important actions in RM; particularly, the capacity to provide evaluation of the impact, frequency and severity of risks in the business operation.

- Risk monitoring: These sets of actions represent the capacity to follow up on what has been designed for managing risks.

- Risk control: This represents the capacity to assure the adequacy of the RM actions, such as risk mitigation, risk transfer and, in general, risk alignment to the policies and strategy.

- Risk application: Policies and solutions for the business processes and the required conditions to keep risk effects under control.

The next section is dedicated to identifying how risk control is developed and to understand how this is related to other risk management actions.

2.2.4. Risk Control Process

In the previous section, the RM processes were introduced and risk control was identified as one of these processes. Risk control is crucial in RM practice. Mainly, because in RM, risk identification, measurement, monitoring and application are processes that can be performed by areas independently, whereas risk control is the alignment of the policies with the practice. Risk control is the verification of the effectiveness of the answers to potential adverse events that can affect the organisation. Mintzberg (1979) identified that performance control, in general for an organisation, is achievable when targets are clear and measurable. In the context of RM, control is primarily associated with the review and observation of risk policy implementation; this implies that activities have to be clear for the whole organisation, given that risk has been defined as variation in the result-objective deviations.

On the one hand, risk control is the risk management process that converts into practice the organisational actions to implement risk policies. risk control includes actions to mitigate risks, assess processes, to review what is happening in an innovation process, and to analyse risk itself (Kimball, 2000). Financial institutions are continuously striving to modify the loss distribution. Factors such as special or uncommon cases influence loss distributions. These affect the decisions of capital allocation, risk mitigation strategies, and in general risk control under environmental issues.

On the other hand, regulation in RM evolves to prevent, or recover from, the most recent corporate disasters. There are different regulations and frameworks for risk management practice; no single one is identified as the generally accepted one according to best practices which includes a dynamic of adjustment and improvement. These regulations currently focus on supervision of regulatory capital and enforcement standards (Ong, 2006). In addition, the analysis in risk control does not indicate the degree of understanding and knowledge of RM at different levels of the organisation. There is no clear identification of the effectiveness of controls or how they can be affected because of environment issues.

There is an assumption in regulation and frameworks that better risk identification, risk measurement, risk monitoring, and better risk control, imply better competitive advantage for organisations. This includes developing capacity for having better insurance programs, hedging strategies, market analysis, identification of customer value, and distribution of the cost along the internal and external capacities. In particular, risk control is represented in a selection of risk actions to protect the organisation against adverse events that affect growth, change potential results and pricing decisions, or as Lam (2003) put it: “The risk management process does not stop at promoting risk awareness or measuring risk exposures. The ultimate objective is to optimize the risk-return of the business; or to put it slightly differently, to effect real change in the risk profile of the company.”

In summary, the concept of risk control is used for all the original approaches of RM, such as in asset management it has been part of insurance programs and it grew and expanded when new areas of risk were analysed. In this research, risk control includes the capacity for mitigating risk transferring risk, and aligning risk management actions . The promotion of risk control involves different people from auditing departments to business development, and it connects policies and their execution. All these links of people, risk areas and RM work require different grades of communication among individuals, among groups and between individuals and groups. To complement the vision of risk control, the next section addresses the concept of ERM and how this concept has differences from the RM traditional view.

2.2.5. Enterprise Risk Management

The previous section explained a particular RM process, risk control, which comprises actions such as risk mitigation actions and risk assessment actions. These actions have been developed individually, according to the risk types in the organisations. RM employees developed skills in risk control for the risk market, or operational risk or any other risk; however, financial institutions have seen the need in their risk management practices to evolve to a holistic view of risk management given some improper past experiences (examples shown in the introduction). This integral view of all these risks introduced the concept of Enterprise Risk Management (ERM). Therefore, the implementation of ERM includes management concepts that apply to the enterprise risk, not individual risks, but the risk analysed for the whole organisation which includes all risk exposures. Dickinson (2001) defined ERM as: “a systematic and integrated approach to the management of the total risks that a company faces.”

Moreover, Dickinson (2001) presented ERM as a dynamic risk management process across the company, with concepts in evolution and applications in development. ERM was born because of the past big losses and the influence of the shareholder value models. However, the core of ERM is the study of Enterprise Risk (ER) where ERM is just the process to manage the ER aligned to shareholders’ objectives. The organisation of ERM in financial institutions connects different types of risk and markets through enterprise policies as is shown in the example of Figure 2-4.

Aston University

Illustration removed for copyright restrictions

Figure 2-4 Example of Enterprise Risk Management framework at Royal Bank Canada (Source RBC Annual Report 2009)

Additionally, Dickinson (2001) brought to the ERM analysis the difference between insurable and financial risks because this is crucial in order to understand risk management practice. The difference of practice in hedging risks and buying insurance has created some practices that are not uniform in the tools used or in the process used to achieve protection. However, such as, in treasury and in assets management, there are similarities in risk analysis methods. What is more important in ERM is to analyse ER with common criteria; for example, profit reduction, and the support of the operation by practices that can be transferred from one group to another.

Thus, the purpose of insuring and hedging is the reduction of potential losses or failures of the strategy. ERM needs to align with the integral analysis of the potential variation of the outcomes of the corporate strategy and those specified in the corporate objectives. The balance between risk retention and risk transfer, through insurance and derivatives, should be estimated based on an impact scale for the strategy results. This impact on the bottom line includes risk analysis of business processes and the review of the capacity of actions to mitigate and control risk.

The integration requires definition, clarity and reviews relating to the many attributes of risks, especially for some risks where quantification is not possible. Moreover, there is a lack of clarity in the meaning of identifying risks, extension, scope and metrics in the context of ER. The ER can be seen differently whether or not the market risks and corporate objectives are aligned. There is no evidence of what the dynamic of risk management is for the integral treatment of risk for the whole organisation and how the new ways of risk control include another group of risks to analyse.

To transform RM into ERM is a strategic step in RM, and as Lam (2003) said: “As a topic, strategic or enterprise risk management... is really just plain, good risk management practise suited up... risk management didn’t arrive on the scene as a holistic practice. Rather it lapped up on our shores in waves.” This step needs to identify a practice under the same philosophical principles in the risk management processes from risk identification to risk control (McCarthy and Flynn, 2004).

Furthermore, the creation of value in an organisation, according to Galloway and Funston (2000), is related to the ERM practice because it is seen as a means to create a competitive advantage (See Figure 2-5). This advantage supports a balance in managing the basics: innovation, integrity and simplicity. Equally, Walker et al. (2003) express the view that the selection of tools and disciplines that help in the holistic organisation in risk analysis has contributed to the strengthening of the corporate governance.

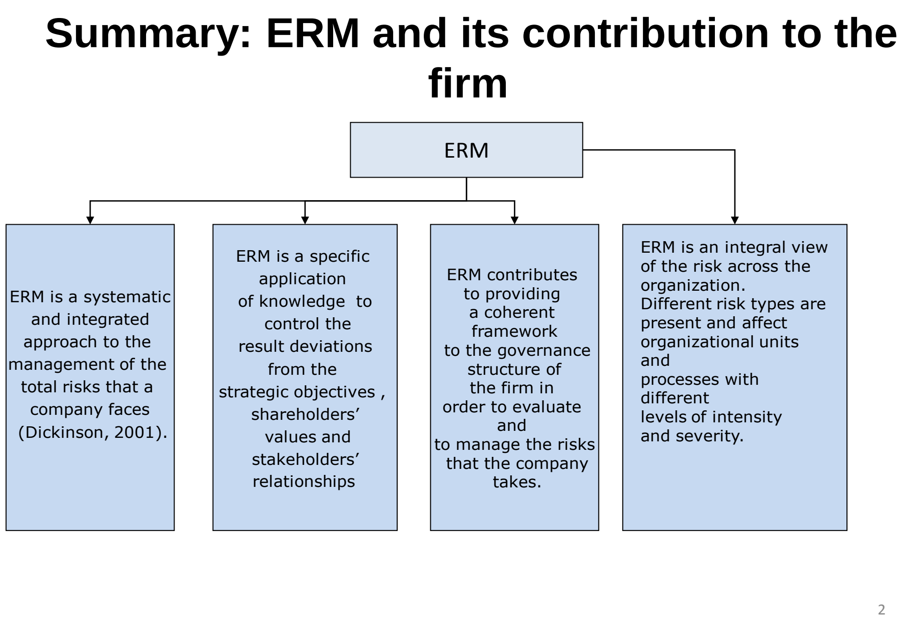

Figure 2-5 Summary of ERM contribution to the organisation (From the author)

Even though there are benefits to achieve using ERM concepts, at the same time, there are organisational issues to solve. Lam (2003) indicates that even having a good RM practice per risk, there are many difficulties in consolidating information and supplying guidelines to the board and senior management in order to answer strategic questions.

Lam (2003) notes that benefits of ERM are based on the concept of integration: integration of risk organisation, integration of risk transfer practices and integration of risk practices to the business processes. Besides, he indicates that, based on the preparation of the organisation for ERM, the expected benefits are "... increased organisational effectiveness, better risk reporting, and improved business performance."

There are ERM benefits from the strategic view to an operational level. Abrams et al. (2007) indicate that: "There are large potential synergies in terms of both risk identification and assessment with respect to adopting appropriate responses to specific risks." Organisation actions and performance need an everyday decision making process that includes risk as a factor to bring to any business discussion (Matyjewicz and D'Arcangelo, 2004). This means to develop standards for risk assessment, create a culture of risk analysis embedded in resource allocation, reporting capacity, change management, communication and knowledge sharing.

Bowling and Rieger (2005) indicate ERM benefits, such as the support to the governance process, better administration of RM costs, and "[t]hrough increased communication, ERM leads to broader understanding and recognition of risks" and many others related to the reduction of risk profile. However, there is not a clear identification of specific fields, activities or resources where ERM can provide value. This study introduces the potential value through better data management, better knowledge creation in modelling processes and better communication among and within teams. In summary, there is a research interest in discovering how ERM provides value as a blend of people, methodologies and resources.

The above points are complemented by Nocco's and Stultz's (2006) work which shows that the ERM value is perceived differently by different stakeholders and is different from a macro or micro view inside the organisation. The macro view includes benefits associated with continuity, sustainability and the strategic capacity of the organisations. The micro view refers to the management risk return relationship, assigning responsibilities and accountabilities to areas and people related to risk existence, and the development of operational capacity to manage risk properly. Also, Peterson (2006) indicates that the benefits of ERM are associated with supporting difficulties to integrate and manage scope and scales of RM areas, data collection and operational risk.

However, there are some additional points that need to be analysed in ERM as a good practice, and as a means of overcoming the problem of silo culture in order to implement the ERM program. One of these is to consider ERM not only as a top-down process, but also a bottom-up process. In ERM it is not enough to know the risk policies; it is important to know the relationship of the implementation, feedback and experience to the strategy. This is crucial to develop risk analysis and control. Knowledge, experience and feedback in an organisation flow in both directions: top-down and bottom-up. ERM requires a policy from the top-down direction, but it also requires developing and implementing the ERM processes from the bottom-up in order to identify ER and to establish an accurate solution of risk mitigation (Lam, 2003).

Finally, ERM targets for implementation the risk mitigation of different risk types (Oldfield and Santomero, 1997; Cumming and Hirtle, 2001; Degagne et al., 2004). This means going further than the limited view of silos and the traditional analysis that has been focused only on casualty and property risks, life risks, work compensation losses, the reduction of costs and the management of disasters (Froot et al.,1994; Banhan, 2004). Thus, the main difference between RM and ERM (Baranoff, 2004c) is in the enterprise strategic view of risk analysis for the whole organisation that is complemented by other differences presented in Table 2-2:

Differential attributes between Risk Management and Enterprise Risk Management (Meulbroek 2002; Lam 2001; Cumming and Hirtle 2001; Dickinson 2001)	
Risk Management (RM)	**Enterprise Risk Management (ERM)**
• Silo, individual view of risk • Specific risk analysis • Tactic orientation • Related to control and minimization • Organisation specific, department or business unit. Concentrated on business events • Disaggregated methods for risk analysis • Responsibility on the functional managers • Performance evaluation concentrated on the particular problem solved • Protection of adverse financial effects of bad events. Earnings volatility protection from the source • Reactive • Specific control on section or division expenditures • Individual risk analysis • The priority is in the portfolio and individual sources	• Global, holistic view of risk • Risk analysis across the organisation • Strategic orientation • Related to competitiveness • Individuals, business units and the complete organisation. Corporate view • Aggregated methods • Governance/stakeholders responsibility • Risk performance evaluation enterprise wide and based on risk • Organisation stability protection. Decision making process based on risk • Proactive • Reviews and reduction of duplication of risk management expenditures • Interdependent risk analysis • Priority can be in portfolio structure, assets modification, strategic movements

Table 2-2 Comparison between RM and ERM

Under this perspective of differentiation between RM and ERM, the ERM analysis includes a cycle that starts in risk identification and ends in risk answers. Shaw (2005) exemplifies this cycle through the Ford Motor Co. and indicates that risk answers the need of reviewing and analysing given the possible changes in the business conditions and processes across the organisation. Each division could provide solutions, but a lack of an integral view, not an ERM approach, resulted in a big loss for the company.

In conclusion, ERM is an integral practice of RM across an organisation based on the strategy that requires integrating the insurable and non-insurable risk analyses. ERM, according to COSO (2004), requires the processes and a solid governance structure to accomplish the tasks that are required. ERM involves different areas, different people, different backgrounds, and as has been mentioned, different ways to deal with risk threats. In an ERM program, RM has a more strategic and holistic view concept, where communication among groups, work coordination, and interaction of people seem to be factors that influence an adequate policies implementation. The wider view of ERM has some benefits and challenges (Galloway and Funston, 2000) that need support to achieve the benefits and overcome the barrier. One of these tools is the Risk Management Information System (RMIS) that is introduced in the next section.

2.2.6. Risk Management Information System

In order to support the risk management processes and to achieve the ERM benefits, a risk management information system (RMIS) is required. Crouhy et al. (2000) identify the requirement of some technology attributes in order to build the RMIS: “The risk management information system needs to be supported by an information technology architecture that is employed in all of the company’s information processing.” This is further complemented by Crouhy et al. (2000): “Banks have many business units, which are engaged in different activities and support different products.”

The requirements that Crouhy et al. (2001) propose include managing data globally using distributed database technology. These authors indicate that a “risk management system approach is not simply an aggregate of applications, data, and organisation; instead, it is born out of an IT vision.” The architecture for risk management needs to gather the key information that is supplied by different areas, in a data-warehouse. The design of the RMIS has to take into account that data is static and dynamic, and to provide an adequate access to all the users. Additionally, it is required to take into consideration the fact that there are different functions in risk management with specific needs, such as the case of trading operations that require systems that support the monitoring of trades, prices and the decision-making process through models.

Moreover, Caouette et al. (1998) argue that a financial institution has to deal with a proper risk information management structure that connects internal and external information similar to internal and external users. Data to manage and data to convert into information appears when a business or an individual is looking to satisfying their financial needs. The processes at the risk organisation are based on: portfolio information, rating agencies, asset-liability control, risk models, default rate analyses, losses, recoveries, credit risk migration, pricing, risk adjusted returns, credit derivatives and many other variables, indicators and decision support actions, and results (Caouette et al., 1998). Additionally, there is a high volume of external data that is managed because in most cases the credit evaluation, as an example, not only depends on the customer relationship with the lender, but also on the relationships with other organisations and the history that has to be considered in the evaluation.

Crouhy et al. (2001) complemented the above points adding to the RMIS analysis: “The risk management system should be designed to support the transport and integration of risk information from a variety of technology platforms, as well as from multiple internal and external legacy systems around the world.” Therefore, the RMIS design requirements are technology for integration and the way to address the solutions through “information collection and normalization, storage and dimensioning, analytics processing, information sharing and distribution.”

3

Table 2-3 ERMIS attributes and issues based on Levine (2004)

Thus, the current design of risk management information systems has, as a main challenge for processes and technology in an ERM program, the design of a system aligned with the integral, comprehensive and strategic view of the organisation (Abrams et al., 2007). This complexity is observed, for example, when the modelling process is looking for aggregation analysis or when each risk organisational section needs to create reports and each one has specific performance measures, problems and resources that are not clearly connected to the whole organisation.

Lee and Lam (2007) add to the discussion of the RMIS challenges, the problem of architecture design from a current system design: " ...IT architecture is divided into separate clusters of IT systems that are owned by individual business units...Each cluster has between 5 to 20 IT systems." This can represent more than 120 IT Systems and the bank in the case study, as others, has grown with this mix of IT systems that combine different platforms and different technologies. This general IT architecture is related to the issue that RM needs to develop RMIS architecture given the variety of systems, each one with data designs and processes defined by the specific business line. Some of the general attributes that have issues to solve in an ERMIS were presented by Levine (2004) in Table 2-3 which includes the whole spectrum, from data to decisions.

Moreover, the RMIS of the organisation needs a specialized functionality regarding the support for different groups interacting in the RM processes, access to data repositories by different people, integration of resources, and conjoint activities among RM people in modelling, analytics and assessment. The functionality needs to take into account different users such for example information in the trader life has a factor to consider that is the pressure to make decisions and act rapidly.. RM not only has a problem with information, but also has more problems with interpretation, people interaction and communication of meaning areas where the information systems need more work to develop.

In summary, this section presented the concepts of risk observing different views and variation of the concept. A differentiation between the definition that is in the mind of managers and the economic and decision theory has been indicated, probability of loss or variance of results. Additionally, RM was introduced indicating the value for organisations and presenting the various ways of identification of the RM processes in the literature., In particular the risk control process was reviewed in order to identify the concept that will be used later in this research,

ERM was introduced and indicated the differentiation from RM, expressing for ERM the attributes of strategic, holistic and integral view of risk management across the organisation, or RM of the ER Enterprise Risk. Finally, as a means to support the RM processes a RMIS definition was introduced. with attributes and issues that are required for the analysis of their relationship with the KM concepts. These concepts are associated with people, processes and technology that require organizing and delivery of risk knowledge to different stakeholders. It has been shown that RM evolved to ERM and that the processes and risk management information systems are in evolution as well, in order to comply with the new regulations and provide support to the financial institutions.

In the following section, the KM concepts are introduced. These concepts include the concept of knowledge itself and a review of the KM concepts, KM processes and the KMS.

2.3. Knowledge Management Concepts

This section concentrates on the KM concepts starting with the knowledge concept up to the knowledge management system description. The next paragraphs include the meaning of knowledge, KM, KM processes and the KM System (KMS) observed from different approaches and indicate the ones that are possibly the best to use in the RM context.

2.3.1. Knowledge

Knowledge is a concept that has had many definitions (Muller-Merbach 2008) and different approaches for its analysis. For example, from the Merrian-Webster dictionary (1990) the definition of knowledge is: "Knowledge is organised information applicable to problem solving." However, the concept has taken the attention of philosophers, researchers and academics to get a more accurate and comprehensive definition.

Authors have presented summaries of definitions of knowledge as Liebowitz (1999) who indicates different definitions of knowledge used under different contexts and assumptions. Based on the nature of this research in the KM field, some of the KM authors' definitions have been taken into consideration. Wiig (1993) indicates that "Knowledge consists of truths and beliefs, perspectives and concepts, judgements and expectations, methodologies and know-how." This view is complemented by others that include the concept of reasoning in the definition, such as Beckman (1997): "Knowledge is reasoning about information and data to actively enable performance, problem-solving, decision-making, learning, and teaching."

An additional summary of views of the knowledge concept is presented by Alavi and Leidner (2001) who indicate that knowledge has been identified as part of the data-information-knowledge chain and as a capacity to influence action. In this research, according to Table 2-4, knowledge is identified as a process for applying expertise. The reason is that risk knowledge is represented in assessment and judgement of the consequences that a risk can bring to the organisation's results. These actions of risk assessment are shared from analyst to decision makers in order to support the steps to follow in the business. All these risk knowledge actions are related to an objective that is to control and to reduce the adverse effects that a risk can have in the financial institution.

Table 2-4 Alavi and Leidner (2001) Knowledge perspective and meaning in KM settings

From these definitions of knowledge in this research, the concept of knowledge used refers to the following three points: the types of knowledge differentiation that the work of Nonaka and Takeuchi (1995) identified with the corresponding model of interaction; the elements of knowledge that appear from the analysis of Davenport and Prusak (1998); and the Alavi and Leidner (2001) review about knowledge management processes and knowledge management systems.

On the one hand, Nonaka and Takeuchi (1995) concentrated on the interaction between two knowledge types: tacit and explicit knowledge. Tacit knowledge is represented by experience, beliefs, and technical skills accumulated in people's minds. Explicit knowledge is the knowledge expressed in documents, data and other codified forms. The interactions among people correspond to the movements from tacit and explicit knowledge to tacit and explicit knowledge on the individual and organisational level. The dynamic is expressed through the following processes, (SECI Model) which contribute to the knowledge creation: (See Table 2-5)

FROM \ TO	Explicit	Tacit
Explicit	Combination	Internalization
Tacit	Externalization	Socialization

Table 2-5 Nonaka and Takeuchi (1995) Four types of knowledge creation process

These processes can be described as follows:

- Combination is a conversion of explicit knowledge to explicit knowledge and represents the systematization of knowledge that includes codification or documentation, that has not been the only explicit knowledge. Polanyi (1958) indicates that this step is not clearly a direct step because it requires a tacit knowledge step before.

- Internalization is to pass from explicit to tacit knowledge; this is the way to learn to work on the solution of the problem through action. This is the learning process that is required to apply knowledge in a further step of a problem or for different problems.

- Externalization: the tacit knowledge is converted into explicit knowledge. This is presented through different means, methodologies, models, metaphors, concepts etc.

- Socialization is the step from tacit to tacit knowledge. This means the conversion of experience and practice in new experience and practice keeping the bases of human relationships.

However, on the one hand, this model has had some critiques from different points of view and show that KM is in evolution. This is the case of Gourlay (2006), who expressed the thinking that different kinds of knowledge are created by the behaviour of different kinds of people. Gourlay (2006) states that there is no reflection in the SECI model about the way people are acting and about systematic and reflective people actions. In general, there are researchers looking for evidence to validate KM conceptual models and at the same looking for a description of KM processes.

On the other hand, Davenport and Prusak (1998) mention four knowledge elements in their definition of knowledge which complement the SECI model. First, the sources of knowledge are: experience, values, context and information. Second, people are considered the original repository of knowledge from information and experience. Third, processes and procedures act as means to retrieve, describe, and apply knowledge. The fourth element refers to the organisation as the place where the knowledge is offered.

The above two concepts of knowledge, types and elements, are indicated by Alavi and Leidner (2001) who not only support the idea that different entities, processes, resources and assets are required to achieve a sustainable competitive advantage based on knowledge assets, but also present knowledge as a competitive factor. This, with a clear understanding of the concept and the identification of different types of knowledge, can contribute to building a knowledge-sharing, creation and application infrastructure.

Besides, Alavi and Leidner (2001) support the notion that the SECI model can introduce innovation and competitiveness, and that the information value is in the identification of strategic opportunities, areas of improvement, creation of new concepts and solutions of organisational issues based on a human intellectual process. In addition to this alignment of concepts, Holsapple (2003) expressed that: “Regardless of what definition of knowledge one adopts and regardless of which knowledge resource has been considered, it is useful to appreciate various attributes of knowledge.” The search for these attributes and the proposed treatment of knowledge as a resource introduces the need of managing knowledge, which is reviewed in the following section.

2.3.2. Knowledge Management

Knowledge management has various definitions, and in this section a review of them will be performed. Wiig (1997) defines KM as: “... the systematic, explicit and deliberate building, renewal, and application of knowledge to maximize an enterprise's knowledge–related effectiveness and returns from its knowledge assets." Similarly, Beckman (1997) indicates that: "KM is the formalization of and access to experience, knowledge, and expertise that create new capabilities, enable superior performance, encourage innovation, and enhance customer value." What is common in these two definitions is the methodical access to experience – knowledge in order to develop enterprise capabilities.

Besides, Alavi and Leidner (2001) adopt the definition of knowledge management as a process, with four sub-processes (see next section), that identifies and leverages the collective knowledge of the organisation in order to compete (von Krogh, 1998). Equally, Alavi and Leidner (2001) state that KM requires more than IT; it requires the creation of a means to share knowledge, information processed by individuals and adapted to be communicated. These points are complemented by the socio-technical perspective of KM that Coakes et al. (2002) have. They identify a framework for KM based on the relationships and interrelationships that people, business processes and technology have to put in place in the organisation in order to accomplish tasks and to achieve goals. Also, Ergazakis et al. (2002) consider the previous definitions and their components, but summarize it as: "Knowledge management (KM) is the process of creating value from the intangible assets of an enterprise." Finally, Burstein et al. (2002) present KM as: "a management technique to maximize the co-ordination and organisation of knowledge."

These above approaches are associated with the way knowledge is considered as a process or a factor that influences the organisational performance. With that purpose, the contribution of Earl (2001) in this research is a guide to understand KM applications. In Earl's (2001) article there is a classification of different KM schools that use three big groups: technocratic, economic and behavioural. The first one includes codification, connectivity and capability; the second commercialization; and the third one, collaboration, contactivity and consciousness. This school classification indicates the need of both technologies and people in any organisation as a way to put KM into practice. The experiences show some organisational orientations through these schools and indicate that there is a need of a blended approach that takes into consideration KM to provide support to people and business processes.

However, there is a discussion regarding KM and technology, as well as, KM and the value in the business processes. The following remark in Muller-Merbach's (2008) article helps to decide how to see technology in KM in this research: "IT support for knowledge management must not be understood as knowledge management itself." Regarding the value of KM in the management process, Liebowitz, (1999) indicates that KM provides a means for the development of innovation, better execution, customer knowledge, product development and enhancement. It provides equally to the organisation the support with the implementation of best practices and the development of better competences, reducing costs of managing operations in different places or conditions and improving performance evaluation systems under a better trust work environment (Liebowitz 1999).

These KM values are related to the development of technology so as to increase what people can do with technology in order to improve productivity and potentially reduce some possible setbacks that are related to people leaving the organisations, which ensures viability and survival of the organisation and better adaptation to the socio-economical environment. However, not all of these benefits are clear in all areas of the organisation because, in some cases, the silo culture limits people interactions for problem solving in technical groups.

According to this view of IT as a KM support and not KM itself, Alavi and Leidner (2001) complement the point of going beyond technology and indicate the need of a strong research process to analyse the role of IT in KM. They add to the relationship between KM and IT the fact that knowledge transfer and effective communication depends on the knowledge bases, overlap and amalgamation among people. Thus, IT is considered by Alavi and Leidner (2001) as a tool for providing knowledge amalgamation and knowledge classification, which are bases for the KMS design and for the contextual information analysis, and indicate that the quality of the knowledge transfer channels is affected by the organisation, the method, and the informality. Additionally, some authors, such as Ferguson and Pemberton (2000), present a set of resources that knowledge management can use for implementation where the emphasis is more on the creation of a map of the means to learn about the subject of study in the different areas of the organisation.

Moreover, the people component of KM is complemented by the model of Chen and Eddington (2005) for evaluation of knowledge creation over time which shows that the organisational benefit “of consistent and frequent knowledge creation process participation increases over time as the match of skills and task complexities improve.” These authors continue by saying that there is a differentiation between the traditional worker and the knowledge worker based on the capacity for screening information or searching for knowledge inside and outside the organisations in order to create knowledge and to support business processes. Work differentiation that is associated with the knowledge creation processes, is divided into formal and structured. People create knowledge in organised and structured meetings that include training programs and time frameworks. These concepts are relevant given the previous notes about the understanding of financial institutions as knowledge organisations creating knowledge every time that a new risk is identified (Shaw 2005).

Additionally, McKeen et al. (2006) state that KM can contribute to organisational performance under different levels of measures of performance, associated with customers, products, and operations. These authors indicate the importance of KM to innovate and to achieve goals of supporting and providing better solutions to the stakeholders. The business processes require the use of the best practices and experiences to learn for future development of the organisation.

In summary, in this research, knowledge is understood as a process of applying expertise and understanding knowledge flows (Alavi and Leidner, 2001) and knowledge management, as the group of processes that coordinate and develop knowledge to create value in the organisation. In essence, with the previous bases the KM processes are presented in the following section:

2.3.3. Knowledge Management Processes

This section examines what the KM processes are, showing different approaches and concentrating on Alavi and Leidner’s (2001). The previous section identified knowledge and knowledge management concepts and these concepts were related to the value that knowledge and KM can provide to the organisation. In this section, the KM processes have been presented basically from the perspective of providing value to the knowledge, as an organisational means to be more competitive.

The description of KM processes comes from many authors (Wiig, 1997;Beckman, 1997, Ruggles, 1997) and they include: knowledge acquisition, knowledge creation, knowledge transfer, knowledge utilization and knowledge storage. Some of these different author's views about the KM processes are shown in Table 2-6:

Processes	Reference
• Acquiring knowledge • Selecting knowledge • Internalizing Knowledge • Using Knowledge • Generating Knowledge • Externalizing Knowledge	Holsapple & Joshi 1997
• Knowledge generation • Knowledge codification and coordination • Knowledge transfer • Knowledge roles and skills	Davenport and Prusak 1998
• Knowledge creation • Knowledge storage/retrieval • Knowledge transfer • Knowledge application	Alavi & Leidner 2001
• Knowledge planning • Knowledge creating • Knowledge integrating • Knowledge organizing • Knowledge transferring • Knowledge maintaining • Knowledge assessing	Rollet 2003
• Knowledge creation • Knowledge storage/retrieval • Knowledge transfer • Knowledge application • Knowledge roles and skills	Peachy, Hall and Cegielski 2008

Table 2-6 KM processes

Table 2-6 presents that there are distinct ways to refer to the KM processes; some authors include the organisation of KM and others review specific activities that can be aggregated. In particular, the activities of the KM processes are described by Holsapple and Joshi (1997) and can be summarized as: acquiring, selecting, internalizing, using, generating and externalizing knowledge up to the identification of processes. An aggregation of these activities is presented in 2001, by Alavi and Leidner, who summarize these processes as creation, storage and retrieval, transfer, and application of knowledge. In the other references presented in Table 2-6, the processes are associated with the definition of roles and maintaining knowledge embedded in the knowledge application and knowledge transfer definitions of the Alavi and Leidner (2001) processes.

These processes (Alavi and Leidner 2001) are looking to create value from knowledge and the dynamic that individuals and groups have in the organisation in order to achieve "effective organisational knowledge management." The organisation can be considered in this research as the vehicle for knowledge creation (Nonaka and Takeuchi, 1995) and the environment where the knowledge is processed (Davenport and Prusak, 1998). This means, from Robbins's (1990) organisation concept, that people interact using knowledge to achieve goals under identifiable boundaries, work coordination and development of the activities of the KM processes. The organisation of the KM processes presented by Alavi and Leidner (2001) is as follows:

- Knowledge creation: The authors state that organisational knowledge creation involves developing new content and replacing the content already in place. The knowledge creation is related to the organisation's social and collaboration capacity to grow knowledge and to validate it as Nonaka (1994) indicates. Similarly, the authors refer to the SECI model (Nonaka and Takeuchi, 1995) and they add: "The four knowledge creation modes are not pure, but highly interdependent and intertwined." Furthermore, they indicate that knowledge creation involves the new content creation, replacements of content and the tacit component creation with knowledge movements at individual, group and organisation levels. Alavi and Leidner (2001) explain the *ba* or spaces for knowledge creation are different according to the SECI model: originating *ba* for socialization, interacting *ba* for externalization, cyber *ba* for combination and exercising *ba* for internalization. Based on these spaces and the SECI modes relationship, the understanding of the means for enhancement of knowledge creation can be followed, and in particular how technology can be used.

- Knowledge storage and retrieval: This process refers to the reality of the need to managing organisational memories; knowledge is created and at the same time forgotten. There are different forms of keeping organisational memories: through databases, information systems, and networks of individuals. There is a difference between individual and organisational memories. The first is developed based on personal experience and are observations, while the second refers to the organisational activities that can be in documents, databases, systems to support decisions, etc.

- Knowledge transfer: This process takes place "... between individuals, from individuals to explicit sources, from individuals to groups, between groups, across groups and the group to the organisation." The authors present different methods and technologies for knowledge transfer channels indicating them as formal and informal, personal and impersonal. These channels can be supported by technology and each category can have a different solution.

- Knowledge application: Alavi and Leidner (2001) indicate that knowledge application is associated with competitive advantage development and for that there are three mechanisms to create capabilities: directives, organisational routines and self-contained task teams. Technology can be involved in the application of knowledge which supports knowledge integration and knowledge application by providing access and updates of directives, organizing, documenting, and automating routines.

2.3.4. Knowledge sharing

In this research, as was indicated in Chapter 1, knowledge sharing is a point to analyse. However, from the description of the previous processes and the literature review, the differentiation between knowledge transfer and knowledge sharing is not clear. For that differentiation the literature analysis of different KM aspects has been used to indicate relationships with other KM processes, identify the different levels of knowledge transfer/sharing and understand enablers or barriers of the transfer/ sharing knowledge process.

The differentiation between knowledge transfer and knowledge sharing can start with the vision of Nonaka and Takeuchi (1995) which relates knowledge creation and knowledge sharing. It indicates that knowledge is amplified and internalized based on the interactions between individuals in an organisation. In 1997, Davenport expressed the idea that knowledge sharing is a volunteer process and thus, distinguished it from formal actions like reporting or structured knowledge-related interactions. Von Krogh et al. (2000) complemented Davenport's (1997) point by indicating that there are steps and enablers in order to convert knowledge into a competitive advantage. The steps include: sharing tacit knowledge that require action from internal people through conversation, fostering the development of a capacity for analysing problems equally through conversation, and creating context for the knowledge sharing process. These two observations about knowledge sharing show a clear indication that knowledge sharing is a support to other processes and relates to people's interactions. This is an important point because knowledge sharing refers to the exchange of ideas, that which does not have to be codified.

Moreover, Alavi and Leidner (2001) talked about knowledge transfer and identify the different levels of knowledge transfer among individuals, individuals to groups and individuals and groups to the whole organisation. These authors indicate that the four main processes can be subdivided into other sub-processes and knowledge sharing, internally and externally, can appear as one. Thus, the two terms, sharing and transfer knowledge, are needed and each require time to get a better understanding.

On the one hand, in 2001, Grover and Davenport defined knowledge transfer as a movement of knowledge from an initial point to a final point under context. Maier et al. (2005) complemented this by saying that it was not only the knowledge movement between two points but also the interpretation capacity. They stated: "Transfer of knowledge implies that the sender is quite certain that the receiver will interpret the data accordingly, (re-) construct the knowledge and use it to actualize the receiver's knowledge in a way that the sender intends."

On the other hand, in 2003, Ipe presented a framework about knowledge sharing, that looked for the clarification of the concept. He expressed the idea that knowledge sharing was distinguished from knowledge transfer, and considered the first as the movement of knowledge among individuals, whereas knowledge transfer was more between organisational areas, departments, teams or groups. Therefore, knowledge sharing has an important influence on KM implementation because it provides connection between people and organisation, and produces dissemination, collaboration, innovation and the acquisition of knowledge (Ipe, 2003). The point with Ipe's (2003) analysis is that knowledge sharing is presented as a process which is influenced by human interaction.

However, the review of the differences between knowledge transfer and knowledge sharing, finds another level of analysis, such as that of Cress and Martin (2006). They express that there is a difference in knowledge sharing between small and large groups. In large groups, knowledge sharing using questions is not very efficient because similar questions come from different people. This means there is a need to create repositories of experience, data and collaboration tools in order to enhance the knowledge sharing; this could be converted into knowledge transfer where the means are more structured. Small and Sage (2006) carried out a review on KM and knowledge sharing, and included the concept of the human factors as part of the processes of knowledge sharing. They regarded knowledge sharing as critical in knowledge creation and found that factors influencing knowledge sharing included: business context, organisational structure and roles, business processes, motivation, means, ability, etc. The study also found that many factors enabled knowledge sharing, such as the strategy link with knowledge sharing and the proper adjustment to leadership, human networks, organisational culture and learning processes.

Size and human factors are not only the points that generate differentiation between knowledge transfer and knowledge sharing, but also between the organisational structures. Knudsen (2006) compared three different organisations and concluded that knowledge transfer is affected by different organisational structures. This is because an incentive system may be required or because a team based organisation design indicates the basis for transferring only within the team or at organisation level, when a collaborative environment is present.

In summary, knowledge transfer and knowledge sharing has been used in the literature in a mixed way; the difference lies in the way that people interact to communicate and whether they use the knowledge in their activities through formal methods or technologies. King (2006a) identifies the main difference between knowledge sharing and knowledge transfer as: "knowledge transfer implies focus, a clear objective, and unidirectionally, while knowledge may be shared in unintended ways multiple directionally without specific objective.” Knowledge can be shared as well with specific purposes when the organisation is looking to create a common understanding of a process, a problem or particular action.

In this research, the concept used is knowledge sharing and the construct is based on the people interaction, the willingness to collaborate and use knowledge of different people. The human factor is thus aligned with the work of Bosua and Scheepers (2007) in that: ”Knowledge sharing is a more subtle concept, and is seen as a dual process of enquiring and contributing to knowledge through activities such as learning-by-observation, listening and asking, sharing ideas, giving advice...” In particular, knowledge sharing has bases in the culture and trust of the organisation in order to develop an informal learning process (Singh and Premarajan, 2007).

One of the issues of knowledge sharing is how to motivate people to share knowledge. Some motivators have been identified as: self-esteem enhancement, or the improvement of understanding of the knowledge; the importance of social exchange, and probably the support from the organisation (King, 2006a). King (2006a) argues that there are some issues with knowledge sharing, such as knowledge factors acquisition and the reception of knowledge, motivation and communication. Moreover, Land et al. (2006) state that the political process of the organisation, where people can have different agendas to develop their work, can affect the KM processes.

Besides, not only motivation is needed for knowledge sharing but also knowledge sharing needs to overcome some barriers. Regarding this Keith (2006) identified an exhaustive list of barriers that include technological and cultural factors and mainly individual ones that relate to communication and people interactions. Keith’s work (2006) is complemented by that of McKinnell (2006) on knowledge sharing between individuals. The article presents a model of knowledge sharing that has components, such as: source, message channel, and receiver feedback channel resources. With this model, the article indicates that there are circumstances, events and actions that modify the potential of sharing knowledge. These are the perceived value of knowledge credibility and motivation from the source, the message, the types of knowledge, scope of knowledge and nature of tasks blended with channel characteristics, degree of formality, direction of the sharing, and whether or not the receiver has the motivation and absorptive capacity.

Now, independent of the discussion of knowledge transfer and knowledge sharing differentiation, there are methods and techniques that support knowledge sharing and transfer; capturing knowledge, in particular tacit knowledge; sharing and then making the knowledge available. Personal experiences, the development of organisational capacity and the capacity of the organisation to avoid the lost of expertise promote many different actions in organisations to capture knowledge. The interest in this research is to understand that the methods application requires a willingness of the source to share as well as the receptor to take the value of the knowledge that it is looking for.

In summary, this section indicates that the KM process can involve technology or not and the difference between knowledge transfer and knowledge sharing. This difference is fundamentally in that knowledge sharing is associated with the willingness of people and not the formal way of using knowledge from different people when they are working together or more defined organisational actions to mobilize knowledge within the organisation. Both transfer and sharing have both barriers and enablers that provide the value; however, the difference is that the knowledge sharing is associated more with the individual, whereas the knowledge transfer works more with the organisation.

There is an open interest in observing the use of technology to support KM processes, particularly knowledge transfer/sharing. Technology that increases the capacity for connecting people through intranets, develops better web functionality or improves information system functionalities. Technology, according to Alavi and Leidner (2001), is involved in the transformation of the information systems to manage the organisational knowledge, and it has been used more to support knowledge that has been codified. However, the interest in supporting KM process implies that it "... must provide the means of capturing all types of knowledge..." In the next section the bases of that evolution of information system to KMS are introduced.

2.3.5. Evolving from information systems to Knowledge Management Systems

In this section the concepts related to systems, information systems and knowledge management systems and the value of technology in RM are analysed. The review includes the identification of the components of KMS based on the knowledge attributes exposed in the previous sections.

A system (Oz, 2006) is defined as: “An array of components that work together to achieve a common goal or multiple goals, by accepting input, processing it, and producing output in an organised manner”. Additionally, a system is related to business processes, as Steven (1999) indicates, whereby a system is an interaction of components that together search to accomplish a purpose, in particular, the business processes that people follow in order to add value to internal and external users of the organisation.

In this research, information (Gupta, 1996) appears when data is transformed into a form of “useful and meaningful to the decision maker”. Information has some attributes that are important in this discussion, such as relevance, timeliness, accuracy, formatting, accessibility, and completeness. Information is required to be organised and put into service in the organisation. For this purpose, an information system and a management information system (MIS) are those that create, process, store, and generate information within and outside an organisation. An information system can be formal or informal. A formal system is a “system that is designed and developed using well established guidelines and principles, policies, procedures to coordinate and facilitate communication between different functional units and the processes they support, and to meet the overall information need of the business.” The informal system does not follow any rules; it is created ad-hoc (Gupta,1996).

Organisations have followed two approaches in order to design an information system (Laudon and Laudon, 2004): the technical approach, which includes operations research and computing; and behavioural approach, which includes social science points of view. Both approaches require as main phases for building a system the following (Steven, 1999): initiation, development, implementation, operation and maintenance. From these points, information systems are understood, in this research, as a means to provide analysis and solutions to the decision-making process and as a step in organisational transformation.

The quote of Marshall et al. (1996) (Chapter 1): “Risk Management is frequently not a problem of a lack of information, but rather a lack of knowledge with which to interpret its meaning” opens an important point regarding the risk management information system. How do we convert the information systems into a system to support the creation of meaning of information and KM? This point of creating meaning from the information has produced some reflections about the systems that support RM processes.

The decision-making process and the results of decisions are sources of accumulated experience that has application to other decisions. This experience creates new knowledge that the organisation can use later. Therefore, to distribute, apply and share this organisational knowledge, a Knowledge Management System (KMS) is needed to support the KM processes. Alavi and Leidner (2001) identified the KMS as the “kind of information systems applied to managing organisational knowledge.”

However, the transition of an information system into a knowledge management system (KMS) requires several components that take into consideration the system design stage. One component is data architecture which includes data in multiple ways, structured and non-structured. The data is required as a means of action and application in a business environment. Another component deals with knowledge attributes of the KM processes that is based on the Alavi and Leidner (2001) KM processes and the KMS components identified by Lehaney et al. (2004). An attribute is a dimension along with which different instances of the KM process can vary (adapted from Holsapple 2003).

Thus the KMS components (Lehaney et al., 2004; Davemport and Prusak, 1998; Malhotra, 1999; Edwards et al., 2005) can be summarized as follows:

- People interactions: KM and Knowledge acquisition are subject to perceptions and agreement. These human interactions require two subsystems:
- Technology acting as support and the way to enable the KM function
- Organisational structures.

There is a need for applications that add interpretation and meaning to the data. However, data interpretation and meaning are not enough. There are ideas, procedures, and experiences and practices that are also important in order to manage and support people's work. Managing the previous points is where the information systems can start the evolution to the KMS, which supports the KM processes and provides capability to use knowledge in the business operation.

The KMS takes into consideration that the bases of knowledge are (Von Krogh and Roos, 1995) the individual minds and their relationships in order to create knowledge. Alavi and Leidner (2001) gave the bases of understanding that KM and KMS require strategies and perspectives in order to apply them in any organisation. This means that the KM and KMS designs are not the same when knowledge is seen as a process, an object, a state of mind, a capability, or access to information. In this review, they found that the KMS needs to be designed to support different kinds of knowledge and their relationships. The understanding of whether knowledge is new or not, which will be stored, retrieved and transferred for creation of a better enterprise, introduces opportunities for IT support.

From, Alavi and Leidner's view (2001) of the organisation as a "dynamic knowledge system," it is necessary to identify solutions regarding knowledge availability, meaning and the relationships within the KM processes. Furthermore, they indicate that IT converts knowledge into a sustainable competitive advantage when it helps in capturing, updating and accessing information to support the business strategy. It is a path to the integration of knowledge with directives, organisational routines and self-contained task teams, supported by IT.

Some other attributes of the KMS are expressed and complemented by additional approaches to the definition and identification of the components of a KMS. Some of the views include the following:

- Bases of artificial intelligence. Ergazakis et al. (2002) opened an important gate on the need to understand the value of IT tools and systems, and the issues of using these means to get better KM processes. There are many different tools and

Artificial Intelligence that can support the processes, but there is a need of organizing the way that these components could be used.

- Hybrid technology. Desouza and Awazu (2005) state: "While the most early deployments were immature and disastrous, there were exceptions. Successful KMSs were aware, to a certain degree, of the need to strongly consider the human factor." The authors classify the technologies in three groups: codified, personalized and hybrid; " a KMS normally employs either the codified or the personalized approach as a design base, though some advanced systems use a hybrid approach." Codified technologies are based on technologies for explicit knowledge, whereby personalized are those that look for knowledge sharing to develop individual relationships in order to create people interaction more as group and less as individuals.

  Desouza and Awazu (2005) identify barriers for the KMS design and point out that there are some barriers to the consumption of knowledge. They indicate that some of the barriers are from the source of knowledge, and others from knowledge itself. The source of knowledge barriers is due to credibility, competency, connections and proximity. Regarding knowledge itself, the barriers are complexity, compatibility and relative advantage. "The term KMS has been a strong metaphor for the development of a new breed of ICT (information and communication technologies) systems." (Maier et al., 2005) This means the organisation of technologies that support information and communication at organisational level.

- Internet use. Jennex (2005) presents different approaches to the KMS design. He included the internet as a tool to use networks in daily work. This with the development of a structure that is common for standardizing software, hardware and data that is available for many users across the organisation. He indicates as well, that internet technology supports the interaction with users, in order to get feedback. In addition, Razmerita (2005) indicates the needs and the functions that the KMS would supply. The needs comprise of identification, affiliation, competency, activity behaviour, accessibility interest and goals. The solutions include content management and means for connectivity with people and social interaction. According to Poston and Speier (2005), the KMS's "facilitate the efficient and effective sharing of a firm's intellectual resources." "KMS implementations, which differ from most information systems (IS) projects due to greater difficulties associated with managing human factors and effectively changing the corporate culture."

- Quality assurance methods. In 2006, Jennex and Olfman (2006) indicate the need to align technological resources quality, knowledge quality strategy and management support to user satisfaction and benefits for the organisation. King (2006a) argues that the KMS is an enabler of the knowledge sharing. Knowledge sharing starts from the individual and includes the process of encode, communicate and explicate.

- Means to use and re-use knowledge. McCarthy et al. (2007) expressed two important points: First, the value of the KMS is for using knowledge to solve problems and support decision processes. Decision processes that at the same time can be based on technology to enhance the knowledge processes. Second, the value appears when it is possible to apply and reuse knowledge within the organisation.

Moreover, knowledge attributes and the KMS need to deal with the association of concepts of business practice. As Edwards (2005) indicated, business processes and KM include the concepts of linking business process, people and technology that interact with the dimensions of tacit and explicit knowledge. Equally, there are barriers to consumption of knowledge that can affect a KMS design. In particular those related to tacit knowledge, such as the case of getting participation of experts. The "experts" do not generally want to be classified as such merely because they know the organisation but also as people who have potential to learn, analyse, do research, explore and overcome barriers in languages, develop common concepts and terms.

Therefore, business processes that are supported by information systems have to deal with the KM processes as well. The information system needs to be upgraded in order to support the KM processes in converting itself into a Knowledge Management System

(KMS). The KMS (Alavi and Leidner, 2001) is based on the subsystems of technology and organisation. The KMS is an information system that can help in many tasks of knowledge access, sharing and application. The KMS is not just technology-oriented; it has to include the social and cultural components of KM (Davenport and Prusak, 1998; Malhotra, 1999) or, as has been expressed by Edwards et al. (2005), the KMS technology and people are important factors for the KMS design and implementation.

From all the previous points, there are some components and attributes that the KMS needs to have: technology for networks, for supporting data architecture, for data mining, for capturing, browsing, searching documents, communication tools, etc. Human components are associated with the organisation and its actions. Actions that need means and spaces to communicate, share and develop solutions to the organisation's problems. In general, means to develop support to manage tacit knowledge and to create a culture of doing better when knowledge is shared.

These approaches to the KMS structure are complemented with the following five points in order to identify components with a means to implement a KMS:

- Chalmeta and Grangel (2008) point out that five phases are required for the implementation of KMS: identification of target knowledge, gathering the target knowledge, classification and representation of knowledge, procession and store knowledge, and utilization and continuous improvement.
- Carlsson (2003) studied the networks for supporting inter-organisational relationships in KM. These services are summarized as follows: Technologies for gathering information/knowledge, technologies for document/content management, technologies for searching and browsing, technologies supporting analysis and technologies supporting communication.
- Bowman (2002) indicates the concept of repository KMS that includes the features: User interface design, text search and retrieval, multimedia search and retrieval, knowledge mapping, personalization, standing queries, affinity group filtering, knowledge directories, collaboration and messaging, gateways to enterprise applications, and information resources.

- Maier and Hadrich (2008) identify the strategies needed to design a KMS have two main approaches: codification which corresponds to a centralized system, and personalization which corresponds to a decentralized one. Codification includes lessons learned, knowledge products, ideas, experiences, and secured knowledge. The personalization strategy includes individual content, ideas, results of group's sessions, and experiences.
- Gottschalk (2008) identifies four ways in classifying the KMS components: end user tools, people to people, people to documents, and people to systems. The last one includes all the KM processes solutions from word processors, groupware, intranets, data warehouses to expert systems, neural networks and intelligent agents.

Thus, some of the main points in a KMS are: socio-technical systems that support the KM process in order to put in contact, through diverse means including ICT, people with other people, with systems and with documents.

2.3.6. The IT business value

The previous point introduces the need to analyse the effects of investing in technology for risk management, in particular to identify if at the same level of risk a higher investment in IT will be converted into a better performance. Alavi and Leidner (2001) as was mentioned in the previous section pointed out that IT converts knowledge into a sustainable competitive advantage.

An aspect to keep presenting mind is that the KMS is not only technology but technology that will provide value to RM. Tanriverdi and Ruefli (2004) pointed out "However, findings to date remains mixed: while some studies find a positive relationship between IT investments and firm performance, others fail to find any significant relationships at all." These authors indicate that firm's performance has two dimensions to analyse return and risk. The risk dimension has not been analysed in depth and they said "By focusing only on the return implications of IT, IS research has implicitly ignored the possibility of a risk/return trade-off."

A KMS has IT as a component even though is not the only one, but the KMS requires the identification of what the best level of IT support should be in order to make RM a better provider of value to the organisation.

Moreover, Tanriverdi and Ruefli (2004) define risk as the chance of loss and magnitude of loss, and based on their analysis they said: "In particular, we examine the notion that managerial interventions in the form of IT investments and activities can affect the risk/return profile of a firm. Such interventions would have the objective for a give level of return of reducing the chance of loss or the magnitude of loss-or both." The reason for them is that "Risk, as chance and magnitude of loss, captures an aspect of performance that is not captured by return or by cost."

However, the value of IT seems not clearly taken into consideration at the time of designing a risk knowledge management system that will provide support to management actions and support activities to increase the organisation's performance. Tanriverdi and Ruefli (2004) stated " Such IT investments can accelerate cognitive processing, provide better information, give confidence to act, improve group decision processes, result in faster decision processes, and by doing so they can help managers to better manage different types of risks"

Additionally: one of the points is the difference between IT value relating to productivity, business profitability and consumer surplus (Hitt and Brynjolfsson 1996) Their results show that IT brings benefits in productivity and consumer surplus but not in profitability. Hitt and Brynjolfsson's (1996) study used three different approaches, one is based on a production model, another a competitive model and the third a consumer model in order to identify variables and relationships. One of the reasons for this result, the authors pointed out, is that productivity can increase and the consumers can feel better service and value from the organisation's offer but the market price of the output is lower (consumers pay less for it), reducing the profits. In financial institutions, specifically the banking sector, IT created value and the profits dropped "[b]y enabling entry and radically lowering prices. This reduction in prices coincided with massive layoffs in the financial services sector."

IT value in e-business is relevant to this research because the bases of a KMS to support RM have some web based components (see Chapter 6). In this regard Zhu et al. (2004) indicated that technology readiness is a factor that positively contributes to e-business value and the size of the organisation is negatively related to e-business value. In addition, e-business is associated with internal organisational resources and for launching an e-business the financial resources and government regulations “are more important in developing countries, while technological capabilities are much more important in developed countries.”

Moreover, e-business, in particular the “online shopping channel” Kohli et al.(2004) provides support for the design and choice phases of the consumer decision-making process providing value through cost and time savings. This point and the previous one also apply to internal users buying and selling knowledge in the organisation as Davenport and Prusak (1998) pointed out. This is consistent with the evolution of e-business that Earl (2000) presented.

In summary, a KMS has components that are people and technology related. The technological tools are a complement to the human factors involved in the KM processes; the business processes are supported by the KM processes when people acting are motivated and able to share their knowledge. As a manner of review, Alavi and Leidner (1999) found that the KMSs include more than technology “encompassing broad cultural and organisational issues,” remarking that the importance of the “integrated and integrative technology architecture is the key driver for KMS.” These authors propose a model for evaluating the KMS based on knowledge/information quality, the intent to use/perceived benefit and use/user satisfaction, and net benefits.

With the review of RM and KM as separate concepts completed, the next two sections refer to the experience of KM in financial institutions and the experiences of KM and RM used to support RM processes.

2.4. KM in Financial Institutions

The KM experience in financial institutions has been studied under a wide spectrum that includes data mining techniques for knowledge discovery, communities of practice and knowledge maps, and technology solutions of web based networks. . In this section, there is a review of KM initiatives in financial institutions and, at the same time, a review of the factors influencing KM in these organisations. Some examples of KM initiatives used to manage general issues of the financial institutions, using techniques and technology, are the following:

- Data mining has been used independently as a means to support the customer focus, risk classification and loss estimation, (Hormozi and Giles, 2004; Chaudhry-SAS, 2004; Dzinkowski, 2002) These actions need alignment with the strategic objectives to be considered as a part of KM program.

- Set up of communities of practice and expertise clusters (Spies et al., 2005) for the transferring of knowledge overseas. However, the specific risk management application is seen as an explanation of claims in insurance, but not in other areas (Spies et al., 2005). Related to this point the knowledge sharing process has been identified as part of the product creation (Desouza and Awazu, 2005) and pricing and Liao et al. (2004).observed that is a process influenced by the business environment.

- Use of conceptual maps (Fourie and Shilawa, 2004) for structuring and sharing tacit knowledge. The application is for the whole organisation, but there is not a clear application in the RM setting.

- Consolidation and integration developed through internal information and knowledge portals (Spies et al., 2005) and web services (Anderson et al., 2005) interrelating technological, methodological and business factors in order to build a competitive advantage.

The previous examples identify various applications of KM that can be extended to several areas in the organisation. However, organisations are dealing with the evolution of information systems to systems that support and develop knowledge in the organisation. According to Keyes (2000), "...we are still dealing with bits and bytes of information. We still haven't learned how to turn it into certifiable knowledge. That's because most of us are still building traditional systems, that is, systems that provide merely tactical information, rather than smart systems that provide competitive advantage – systems that provide knowledge." From this comment, a point to make is that the creation of a competitive advantage is related to the systems that support knowledge in going beyond the tactical information, and that there is room to improve.

In the process of using more than tactical information and using better information systems that support knowledge, Gibbert et al. (2002) identify some examples in financial organisations. First, Old Mutual, the largest Insurance Company in South Africa, uses the knowledge systems to develop products and support one of the core business processes, specifically, to screen applicants of medical insurance and not just some data or information supply. A second example is Skandia, where they developed the capacity to connect brokers, banking and retail customers in order to build strategic initiatives based on knowledge expansion.

Applications of KM in financial institutions can be found as they are in the previous examples; however, there is a group of barriers to overcome identified by different scholars. The development of KM programs with strategic orientation can be managed under different work environments, and as Liao et al. (2004) indicates: "Knowledge is a very important resource for preserving valuable heritage, learning new things, solving problems, creating core competences, and initiating new situations for both individual and organisations now and in the future."

In the case studied by Liao et al. (2004), it was found that when a good relationship between the organisation and the employees exists, these employees are willing to share "working knowledge and experience with colleagues voluntarily and unconditionally." They also found that in the case of a poor relationship, the employees could not be motivated to share knowledge with coworkers. In conclusion, Liao et al. (2004) identified work satisfaction as a factor that influences knowledge sharing in a financial service organisation.

Julibert (2008) notes, to complement the previous study, that there is an interest and need for “greater access to information as well as more open communication with colleagues.” However, there is a barrier to overcome that is related to the fear of sharing. “The fear of disruptive intrusions to the creative process and the influence of personality and national culture on the willingness to share were raised by some interviewees.”

In addition to recognizing that good relationships improve knowledge sharing, it is necessary to identify intellectual capital as a valuable source of development of financial institutions. Serrano-Cinca et al. (2004) and Mavridis (2004) were interested in the intellectual capital value for the financial institutions. They first studied Spanish Saving Banks and classified these financial institutions in terms of their use of transparency practices and support for e-services. The second study indicated that good results in the usage of intellectual capital, and less emphasis on the usage of physical capital, could provide a better performance.

These points were complemented by Mavridis and Kyrmizoglou (2005) who obtained similar results showing a high correlation between value added and human or intellectual capital; however, Sahrawat (2008) indicates that: “Banks and financial institutions, which are rich in IC (human, customer, and social capital), are in danger of becoming subject to ‘IC walkouts’ if they resist accounting for the hidden value that exists in IC and its constituent elements.”

Furthermore, Al-Shawabkeh and Tambyrajah (2009) state: “It is crucial for banks to leverage their knowledge resources so that they are able to respond to deal with the undoubted major strategic challenges that exist.” Their study indicates that in the credit process, a KM based indicator system can show the KM-performance of the banks. This system provides a basis for benchmarking the financial service industry. In summary, as Bontis and Serenko (2009) argue, referring to the intellectual capital, it is important “to recognize that measuring and strategically managing intellectual capital may in fact become the most important managerial activity for driving organisational performance.”

In addition to the search for indicators and metrics of KM in financial institutions, it is important to review how the business processes in the financial institutions are supported by KM practice. Therefore, the application and understanding of KM in financial institutions is not only for local internal processes, but also for developing capacity in the development of operations in different countries. Regarding this point, Spies et al. (2005) performed a study and concluded that management at Allianz Group was gaining when knowledge sharing was stimulated across different lines of businesses and various organisational entities within Allianz. At the same time, the organisation decided to implement a better document and expert search from various information resources in order to support the knowledge sharing process.

The good relationships, the leverage of intellectual capital value and the value of knowledge sharing require other organisational actions. One of these is mentoring in order to improve the KM practice in the financial institution. Karkoulian et al. (2008) indicate: “Results suggest that informal mentoring is highly correlated with KM; whereby the more employees practice mentoring willingly the more knowledge will be shared, preserved, and used within the organisation. However, there was little support for formal mentoring.” These authors continue: “The results suggest that management should be highly supportive of informal mentoring as a means to capture and retain organisational knowledge.” Mentoring is an action that can be part of the daily practice in the organisation which can stimulate the knowledge sharing and promote shared solutions to internal and external issues.

Additionally, Qin and Liu (2008) brought to the analysis of KM in financial institutions the work related to the issue of globalization and the need to act properly in KM. They note that culture shock and a good transfer of knowledge from foreign banks to the local ones can improve the results. “The data shows that most banks who get foreign partnerships feel a “direct effect”; they have improved their capability of financial innovation, both in organisational structure and products and services by transferring management knowledge from their foreign partners.” This result adds a new element to the financial institution KM programs- cultural differences. This element was analysed in order to share knowledge and create new organisation partnerships in different countries.

Even though there are new products, Curado's article (2008) indicates "the innovative image banks present to customers doesn't rule in the knowledge management strategy of the bank. Apparently innovation is only strictly allowed in the commercial department." Equally, this point is expressed by Roithmayr and Fink (2008): "Currently knowledge management is used in an unbalanced manner and not considering all knowledge-intensive processes." Furthermore, there is room to work on the regulation of financial institutions which can be based on the experience of the financial industry and the market difficulties they have had. Regarding this point, Bodla and Verma (2006) indicate: "An efficient management of banking operations aimed at ensuring growth in profits and efficiency requires up-to-date knowledge of all those factors on which the bank's profit depends."

In summary, in the financial institutions industry there are various applications and different barriers to overcome in the implementation of KM. Curado (2008) summarized this by saying that his paper reflects "the knowledge management strategy most valuated in the banks is similar to an exploitation knowledge management strategy – leveraging knowledge; distributing knowledge and diffusing knowledge." In contrast, Curado (2008) points out that banks provide less value to knowledge management exploration, innovation, new ideas implementation and experimentation. The implementation of KM needs to develop solutions to some other strategic actions of the organisation as well as develop competitive capacity according to the regulation and internal circumstances.

2.5. RM and KM together in Financial Institutions

The relation between KM and RM is not identified in the literature; however, the influence of knowledge in risk management can be observed in the literature. This section introduces the work that is found in the literature which combines RM and the use of knowledge capacity through some initiatives that were started by organisations. Even though these examples of knowledge application to RM are identified, the examples are isolated without a clear systematic treatment of this knowledge.

The RM and KM relationship can appear in the creation of financial institution products. Mitchell (2006) analysed product development, which in a financial institution corresponds to packing risk management agreements and to putting them in the market as offers. “Successful product and process design depends on management’s ability to integrate fragmented pockets of specialized knowledge.” This indicates that integration of knowledge can contribute to supporting strategic actions. Strategic actions have risks and the organisation needs to learn how to manage them. However, RM and KM relationships in financial institutions cannot be analysed only regarding products as there are other actions to review.

One of these actions was analysed by Jamieson and Handzic (2003) who presented RM as a process to identify risk, as well as provide security and control for the KM infrastructure and systems. The KMS assists employees to use knowledge, to improve coordination and to control knowledge overlap. The steps required in the risk management analysis on the KMS include: an exhaustive identification of risks which evidence the vulnerability and requirements of control and learning from the experience, introduction of the auditing process, security and control concepts to use and steps to apply to the KMS. Additionally, Jamieson and Handzic (2003) include the context of culture, technology and commitment as the first step in risk analysis.

2.5.1. Risk management and knowledge

Marshall et al. (1996) indicated issues of risk management and introduced the concept of knowledge as part of the main issues to solve: dysfunctional culture, unmanaged organisational knowledge and ineffective controls. To this view, the additional point is to analyse knowledge as a factor to reduce risk (Dickinson,2001) and consider knowledge as an influential factor in RM (MacGill and Siu,2001), keeping in mind that financial institutions have been identified as information and knowledge businesses (McElroy, 2003). Thus, based on the KM theory, three points in order to observe the value of knowledge on RM are: First, identification of the ways to transfer tacit to explicit risk knowledge and vice-versa (Nonaka and Takeuchi,1995). Second, understanding the influence of information in the production of risk knowledge (Choo, 1998; Weick, 2001), and third, the way that risk knowledge is organised (Wiig, 1993).

In the search of these previous three points, Dickinson (2001) suggested a specific analysis for operational risk. Operational risk can be reduced if there is more knowledge capacity because people are involved in managing the processes; therefore, errors, fraud, failure and disruption can be avoided. However, the studies do not show explicit relationships or empirical evaluation of the relationships between RM and KM; they show the need or the opportunity of potential KM use in RM. Dickinson (2001) went further than MacGill and Siu (2001). Dickinson points out that knowledge contributes to control, business strategy and underwriting processes because they depend on human actions. This can be that the dynamic of ERM and RM could include a clear knowledge sharing capacity.

Another important point that Dickinson (2001) makes is the need to be prepared for contingencies. There is, according to him, a requirement for contingency plans to continue with the business in case an adverse event appears. The contingency and business continuation plans have to be part of the strategy implementation and possibly a KM issue to solve. In summary, the approach of KM as a way to support RM and ERM takes into consideration the interaction that risk analysts have. This KM approach looks for creating risk knowledge from experiences, data analysis and the particular enterprise environment where they interact.

2.5.2. Risk Management, Knowledge Creation and KM processes

The previous section pointed out the interactions among risk management people. These risk analysis interactions to create knowledge, before and after adverse events, recall Shaw's (2005) concept that new risk analysis implies new knowledge. Thus, risk analysis and the RM processes in general need risk knowledge creation that according to the SECI model (Nonaka and Takeuchi 1995; See section 2.3.1) could be expressed through:

- Socialization: social interaction among the RM employees and shared risk management experience
- Combination: merging, categorizing, reclassifying and synthesizing risk in the risk management processes

- Externalization: articulation of best practices and lessons learned in the risk management processes
- Internalization: learning and understanding from discussions and quantitative-qualitative risk management reviews.

Equally, in the context of this research the KM processes (Alavi and Leidner, 2001) have a potentially important role as a means to improve working skills in RM practice.KM processes might improve the capacity of the teams in order to enhance the ways they share knowledge and improve the tools that they use (Wang et al., 2006). These KM processes could be described as follows in the RM context:

- Knowledge Creation: In RM, new risk implies new ways to measure it and to identify the potential effects that it could have. Acquisition, synthesis, fusion and adaptation of existing risk knowledge are all part of the way to understand new and current risks (Hormozi and Giles, 2004; Chaudhry-SAS, 2004; Dzinkowski, 2002). Zack (2003) indicates that Capital One and Lincoln Re (Acquired by Swiss Re) transformed the organisations into learning organisations; they created products and risk management solutions to offer to selected customers. They learned from this experience and were able to offer new products and solutions.

  In 1996, Keltner and Finegold indicated how the banks' learning-training process was important to develop the organisations: "Banks can increase skill levels and reduce turn over by creating a new employment contract that emphasizes competence-based career ladders." This comment signifies a different kind of strategy to create and to improve knowledge. Citibank was a leader in product development, increasing and sharing information among areas or with some organisations, all based on the development of knowledge of customers and distribution channels. California Federal Bank (later acquired by CitiGroup) had a step forward Integrating investment operations into branch operations. The same as Harris Bank in Chicago (Acquired by Bank of Montreal) that developed better customer relationship management and new customer solutions development.

- Knowledge Storage and Retrieval: RM actions and methods require codification, organisation and the representation of risk knowledge. They include the activities of preserving, maintaining and indexing risk knowledge (Basel II Accord, 2004). Zack (1999b) expresses the importance of the use and reuse of knowledge in risk management through the example of Lincoln Re. This organisation designed a system that was used for "capturing and distributing medical risk knowledge" using integration of new knowledge and that already existing to "create even more valuable knowledge." Zack (1999b) concludes: "Lincoln Re developed highly innovative knowledge not only about assessing risk, but also about how to codify, structure, distribute, leverage, and market that knowledge using expert systems."

- Knowledge Transfer: ERM is a multidisciplinary work and an interdepartmental development. ERM and its holistic view of risk across the organisation requires risk knowledge dissemination and distribution in order to support individuals, groups, organisations and inter-organisations to develop RM capacity (Desouza and Awazu, 2005; Spies et al., 2005). LeaseCo provides good environmental analysis and the capacity to identify opportunities, as well as, (Zack, 1999b) transferring knowledge across the organisation that produces competitive advantages which are risk-protected. Maier and Remus (2003) describe German financial institutions in the implementation of a project for knowledge sharing between the core business processes and the business units. This project had as one of its main purposes to "improve knowledge flows within business processes" with an orientation to support risk in transaction management.

- Knowledge Application: Risk knowledge can be converted into a competitive advantage for financial institutions willing to adopt best practices, and develop products and methods for risk control (Gibbert et al., 2002). The application of knowledge, according to Zack (1999b), supports the conversion of LeaseCo (Leasing Company) into one of "the most knowledgeable firms in the industry regarding this premium market."

Although, examples exist like the one presented by Maier and Remus (2003) which links business processes with KM, and in particular RM, there are open questions about the use of the knowledge of the top management team for making decisions (McNamara et al., 2002). These open questions are equally related to the importance given to the knowledge management system (KMS) in risk control and ERM. Even though there have been KM experiences in financial institutions, as indicated in the previous section, they have not been clearly associated with RM or directly related to the issues that have been identified in terms of KM and RM.

In particular, in a financial institution, an intra-organisational knowledge transfer process in risk management can be required. There are five stages that people need to follow for the knowledge transfer: identification, negotiation, selection, interaction and conversion of knowledge and actions (Chen et al., 2006). However, the KM processes in the financial institution can be affected by factors (Kubo et al., 2001) such as: trust in personal relationships, intense communication, the search for the benefit of personal good will and inter-firm collaboration, (See Table 2-7 for a KM and ERM summary of people, process and technology).

Where are People, Processes and Technology in KM and ERM?

	KM(Alavi and Leidner, 2001)	ERM (Dickinson, 2001)
People	▪KM is embedded in culture and individuals ▪Knowledge has to be shared ▪Perspective of knowledge includes a state of mind ▪Cognitive elements: tacit and explicit ▪Individual memory ▪All processes involve people	▪Operational risks & human errors ▪ Choice of resources ▪ Behind processes and risks ▪ More knowledge lower risk ▪ Organizational structure
Processes	▪KM processes identification ▪Knowledge is a process ▪Process analysis to use IT	▪Risk impact in processes ▪Definition of process actions and choice ▪ of resources
Technology	▪IT supports KM processes ▪Perspective of knowledge includes the "how" to access information ▪Creation of the KMS	▪Company's results affected by technology ▪Technology risks ▪Selection of systems and availability in order to support processes

Table 2-7 A view of people, process and technology in KM and ERM

2.5.3. Some aspects of RM practice and KM

Besides, the above points of risk management processes can be affected by a lack of the organisation of knowledge processes. Organisations that need actions to compensate low capacity to manage communication, working coordination and technological support in risk management practices as the following examples of weaknesses show:

- A specific capacity in a RM environment is the application of prediction and classification models that are part of risk control. This is related to the development of tools for risk assessment, which needs people and technology together to avoid weak experiences as it was reported by Burstein et al. (2002). The weakness comes from a financial service technology and the knowledge development of the organisation without alignment is based on sharing experiences, quantitative analysis and the analysis of results. Knowledge about customers is crucial in lending (Keltner and Finegold, 1996) and the experience of developing capabilities for good customer knowledge can be a good practice for credit subscription and for managing price structures for products (Keltner and Finegold ,1996).

- Bank business complexity modifies the risk exposure and the cost of knowledge shows the need for managing the understanding and use of information rather than information itself (Sutcliffe and Weber, 2003). In particular this applies to risk management because of the complexity of financial products, high volume of transaction creation, lack of control, high volume of information, and cost driver as the only important factor to manage. These points can reduce the capability to react in difficult and opportune times. An example of taking advantage of “market shift” are Delta Dental Plan and Merrill Lynch that have used service, information and people support to develop competitive advantages (Keltner and Finegold, 1996).

- Financial institutions have a particular interest in learning from RM experiences. Edwards et al. (2005) state that for organisations in general, there is an emphasis on acquiring knowledge and problem solving capacity to increase the orientation to people and processes. This knowledge sharing process needs improved stimulation of learning systems in order to review business processes and to discuss the results and adequate diagnostic control systems (Simons, 1999).

- There is an emphasis on the cost of integrating risk analyses, control, and risk policy creation, deployment and application (Cumming and Hirtle, 2001). The different systems in RM do not appear integrated because financial institutions can be born from the amalgamation of independent business. This new business model, under the same administration, looks to introduce deeper services offered to their customers with different systems that require alignment.

- Financial institutions might require support for the construction of a Risk Knowledge Portal in order to connect many sources of experience (content integration), explicit and tacit knowledge (See Section 2.3.1 and Table 2-8 for examples), measurement process, and the capacity to manage operations at an acceptable cost (Firestone, 2000; Kesner, 2001; McNamee, 2004; Detlor, 2004, Spies et al., 2005; Warren, 2002). The risk knowledge portal needs to answer how it provides access to content, connect people and at the same time provide access to applications or data to work under the same environment and network standards. A reduced level of managing knowledge-based risk in projects can be a cause of reduced IT project performance and organisational project competence (Reich 2007), in particular, ERM projects and new IT support for RM processes.

- Risk management needs capacity to understand the interactions with the external customers and the solutions provided (Oldfield and Santomero, 1997) by the financial institutions. As was presented in the previous point, financial institutions might, for example, need to develop more capacity for working with different groups as well as support access to common web services.

Type of knowledge	RM environment	RM actions based on knowledge
Explicit	Models outcome	Coordination of several applications and structures
	Documents-policies	Data architecture and datamarts updating for different risks
	Methodologies	Early warning systems
	Findings	Analysis of business environment
	Decisions	Indexed documents, emails
	Solutions	Communication different areas
	Reports	Interpretation of the outcomes
		AnalysisInvestment/ capital allocation
		Learning and development
Tacit	Judgement	Sharing Lessons learned
	Understanding the problem	Develoment Metrics and performance evaluation based on risk
	Assessment	Modeling process and outcome
	Project management experienc	Product & service creation and understanding
	Policy intepretation	Relationship between customer and company
	Business practices	Reporting structures
	Intepretation of results	Perform risk assesment, classification, simulation etc
		Provide Training
		Follow up of Transaction

Table 2-8 A view of types of knowledge in a RM context with RM actions

In summary, many actions and decisions in RM are potentially related to KM in different dimensions. For instance, the assumptions behind the decisions in hedging or investment can be different and the lack of sharing them can create RM issues. Controls are not enough; what is needed is the search for the truth outside of the isolation of people and provision of knowledge access. What is needed is to develop the means for transferring knowledge, managing insufficient knowledge of the operation and the search for the lever assessments of the lessons learned, understanding of the present and forecasts through knowledge. processes and using multiple tools for RM implementation.

2.5.4. Risk Management and Knowledge Management Outcomes

Another way to observe relationships between RM and KM is to consider that a KM program has as an outcome the innovation and knowledge creation as a process. From the RM point of view, there is a potential risk affecting organisations and society when new knowledge is introduced. This is related to a new product introduction which can have risks associated with it, such as, reliability or life span. Equally, something more general, like a science theory that is converted into technology, can have negative effects if it is not well managed. For example, nuclear energy (Bischoff, 2008) or when financial products are introduced and the assumptions and policies can affect the organisation performance.

Finally, there is a possible search of RM and KM relationships through the concepts of strategy, information technology, the use of information and the evolution of information system to KMS. Using these four concepts the literature indicates:

- First, risk and knowledge are strategic for the organisation (Noy and Ellis, 2003; Alavi and Leidner, 2001; Dickinson, 2001). Risk is an important concept to deal with in strategy design, and KM and ERM are considered important pieces in the building of strategic competitive advantages for the company.
- Second, Information Technology and risk mitigation refer to the possible areas where KM contributes. This contribution is through sharing the experiences in claims management in international insurance companies or through credit risk management in banks, risk quantification and integral risk analysis(Oldfield and Santomero, 1997 Cumming and Hirtle, 2001; Degagne et al, 2004).
- Third, value and cost of information, is associated with the proper use of information from the point of view of the value that provides the understanding of information. (Sutcliffe and Weber, 2003). The cost of knowledge introduces the need to manage the understanding and use of the information rather than the information itself.
- Fourth, are the opportunities to apply KM to ERM that appear from the surveys that consultants applied to risk management groups. (Ernst & Young, 2001; Tillinghast-Tower Perrin, 2000; CAS survey, 2001; McGibben, 2004; See Table 2-9 for more details). The ERM conceptualization can help to understand how to apply KM to ERM and identifies opportunities for designs of the Knowledge Management System in insurance and banking.

Strategy-Risk-Knowledge Relationship	Noy and Ellis, 2003; Alavi and Leidner, 2001; Dickinson, 2001	Risk is an important concept to deal with in strategy design KM and ERM are considered important pieces in the building of strategic competitive advantages for the company
Information Technology and Risk	Oldfield and Santomero, 1997 Cumming and Hirtle, 2001; Degagne et al, 2004	Identification of the Risk Management role in financial institutions showed areas where KM might contribute to risk mitigation. This Risk Management role in the financial institutions is clearly related to KM given the importance of information and technology in risk quantification and integral risk analysis across the organisation
Value & Cost of the information	Sutcliffe and Weber, 2003	The cost of knowledge introduces the need of managing the understanding and use of the information rather than the information itself
Opportunities for KM application to ERM	Ernst & Young, 2001; Tillinghast-Tower Perrin, 2000; CAS survey, 2001 McGibben, 2004	The ERM conceptualization can help to understand how to apply KM to ERM and there are identified opportunities for designs of the Knowledge Management System in insurance and banking

Table 2-9 Classification of experiences to show KM and ERM concepts together

Even though the literature for the discovery of RM and KM relationships is limited, because each discipline has developed independently and identifies characteristics and applications in each field, there is a need for enterprise-wide answers regarding KM concepts to use in RM. These concepts are not explicitly included for RM practice. Not only are the principles of integration and consolidation missing, but also is the search for the way to develop capacity for managing multiple business units gaining synergies and sharing experience in order to provide better answers, service and products to the customers.

From this enterprise-wide evolution of information systems to knowledge management systems and enterprise integration of multiple businesses based on risk management, appears questions about the existing capacity to support with KM the RM practice. In particular for risk control and ERM implementation. These questions need answering under the understanding of RM as a system and ERM as a system that combines different other systems across the organisation implying capacity for integration and consolidation of RM practices as Dickinson (2001) pointed out.

On the whole, as Francis and Paladino (2008) express, there is a need to understand other variables different from technology; “Best practice organisations invest more heavily in a range of tools and infrastructure than do sponsors to capture information, conduct risk analyses, and communicate results throughout their organisations.” This, in the context of this research, means the systematic search for understanding people’s knowledge, technology and processes best practices to improve RM.

In summary, financial Institutions are affected by actions in RM and KM: “Financial conglomerates offer a wide array of products that imply potential liabilities and risks that are increasingly interdependent” (Liebenberg and Hoyt, 2003; Cummings and Hirtle, 2001). In this KM and RM context, the higher exposure means the need to identify how to support an integral view of risk practice that goes beyond individual technology used by individual risk management practices (Liebenberg and Hoyt, 2003).

2.6. Gap analysis and research opportunities

This review of the literature regarding the concepts of the KM and RM disciplines identifies a group of gaps and opportunities when KM and RM are analyzed together as valuable support for strategy in financial institutions.

From the review it is identified that KM and RM (Sections 2.2.2; 2.3.1) play an important role to manage two pillars of the financial institution that are risk and knowledge. What has been observed is that the actions in each discipline are separated. At the same time there appears some evidence (Section 2.5) that the conjoint treatment can provide benefits to the organisation; keeping in mind that knowledge is a means to mitigate risk.

The literature shows that the KM and RM concepts are the support for the strategy and service operation of the financial institution and the search of reducing the performance goals. Equally, it is observed that the RM processes are based on human actions that require knowledge to be performed (Sections 2.5.2; 2.5.3). Additionally, from the organisation theory the human relationships are identified (Section 2.1) as the engine for achieving the organisation purpose.

Human interactions are part of the processes development and the processes development is supported by technology. Technology provides value for mitigating and improving the risk management experience. People interaction and human interaction with technology in an organisation structure provide the elements to build a knowledge management system in the organisation.

However, though the theoretical bases of each independent discipline KM and RM are identified the literature does not show RM and KM acting together. There is no a clear integration or common work to solve risk management issues using KM capabilities. There is no evidence indicating a policy to improve the RM processes through the KM processes. The lack of this view of KM supporting RM produces an opportunity to discover variables of the KM processes that can influence the RM processes. The examples that illustrated the review of the literature are composed by KM applications and RM needs that belong to a wide spectrum from data mining to product innovation, from customer relationships to managing claims or the effect of the presence of adverse risk events.

2.7. Summary

Thus, in this chapter a review was presented of the RM and KM concepts pointing to technology and people aspects that are important in this research and will form the bases of the identification of the research variables and items describing them.

Section 2.1 of this chapter introduced the need to analyse the management of information, and uncertainty in an organisation, and organisation design. Section 2.2 indicated the concepts of risk management including a review of the concept of risk, risk management processes, risk control and enterprise risk management. In particular risk has been seen as a variance of results in the organisation and risk management as a strategic part of the organisation development. The concept of risk control was identified as the way to verify the implementation of the risk management policies and ERM as risk management for the whole organisation. One point that was presented was the risk management information system, the current situation and the requirements for a better support for the RM processes.

Section 2.3 presented the concepts related to knowledge management from knowledge definition to a knowledge management system. The knowledge management processes were defined and the transition from information systems to knowledge management systems was indicated. The review of this transition, the socio-technical concept, and the technology value were discussed identifying the value of people and technology as components of a KMS. The literature review described some of the risk information systems components but no one in risk management is referring to knowledge management. Conversely, the literature of knowledge management presented very few articles talking about risk management. In particular there is no clear mention of the variables associated with the RM processes. The search for constructs that describe the knowledge management concepts in the RM settings therefore has to start from the basis of identifying items that could describe the construct.

Sections 2.4 and 2.5 indicated KM applications and KM and RM approaches in financial institutions, again developed in an isolated way . There are no knowledge management concepts used in the terminology of RM/ERM documents, however, some examples of KM applied to RM specific problems were found in the literature, and so open the analysis of the bases of this research regarding KM applied to RM and ERM. In the next chapter the research model and hypotheses have been formulated. The chapter describes the sources of the variables as well as the selection of items, and indicates the selection of the risk management dependent variables.

3. Chapter Three Research model and hypotheses

The statement from Marshall et al. (1996) in the introduction of this document is a motivating one because it refers to the lack of knowledge needed to provide meaning to the information in risk management. The search for understanding of the relationship between KM and RM processes can be important in order to discover the way to reduce this lack of knowledge and increase the meaning of the information in risk management. Similarly, it was indicated in previous sections that a financial institution is based on risk and knowledge. This suggests the value that knowledge might provide to the organisation of RM and to the financial institution. This value is based on the use of knowledge to reduce uncertainty and to discover the risk rules applicable to the business processes and strategy. Then, in this chapter the objective is to identify the main research components required to discover the relationships between RM (risk control and ERM) and KM in financial institutions.

This research in the search of relationships between two disciplines has been enriched with the knowledge attributes that a risk management employee can deal with in risk management actions and decisions. The knowledge attributes are several, but this research used only those that are closer to RM experience and KM initiatives indicated in the previous chapter. The knowledge attributes (Holsapple, 2003) appear in the items used in the variables identification: mode, which is the classification in explicit and tacit knowledge through documents and people relationships; applicability of knowledge to different risk management problems; use of the knowledge for specific problems or for more general ones; validity of knowledge given the level of accuracy that is required in risk assessment and solutions to problems that can be shared and creates trust; and volatility of knowledge given the rapid changes that risk management experiments.

Thus, the hypotheses in this research are expressed as the existence of a relationship between the variables describing the KM processes, risk control and perceived ERM value in terms of people, process and technology. This relationship identification is expected to be the guide to organise a KMS, which supports RM, through risk control and ERM, and to align KM processes to business processes. All of this is in order to obtain risk control and ERM efficiency and effectiveness. Both ERM (Galloway and Fuston, 2000; Dickinson, 2001) and KM take a holistic view (Alavi and Leidner, 2001) of the enterprise and it seems that these disciplines, when working together in the same direction and complementing one another, can handle the risks affecting financial organisations as a whole. However, the disciplines have developed separately, and in order to improve the organisation's performance, the identification of insights into joint efforts of both disciplines is needed.

The literature review (See Chapter 1 and Sections 2.4 and 2.5) exposed some points that are the support for the aim of this research given the implications that they have in the RM processes. Some of these points were that the reduced risk control appeared when the organisation was growing, and at the same time communication suffered because of growth. As well, the information system required more functions and provides more answers to different groups in the organisation. Particularly, the capacity for prediction of possible results in the organisation is part of the need to support and to take into consideration in the system design. Another point that emerged from the literature was the need to coordinate activities and people from different areas in the financial institution. The reason for this might be that more people from different areas with more time would provide better service; thus, a better knowledge sharing process and possibly the use of better technology supporting the financial institution operation is needed.

Based on the literature review and the identification of gaps without the identification of any scale to use in the search of the KM and RM variables a search of items and variables was performed. The following sections describe the item and variable identification.

3.1. RM interdependencies

In RM there are some interdependencies associated with people, process and technology in the context of risk control and ERM. Moreover, when the organization performs the requirement analysis for the design and the use of information systems, Systems that provide to the organization better capabilities to support RM and organisational competitiveness. These points were taken into consideration to introduce the hypotheses, variables and items review:

- Francis and Palomino (2008) express the idea of the difference of viewing separate risk areas from the integral view: “The identification, evaluation, and quantification of risk takes place at the operational level, resulting in a risk profile. A team consisting of risk owners at the operational level, internal audit, downstream departments, compliance, and privacy creates risk profiles.” This means the creation of blended working groups to develop ERM and to achieve the goal of integral understanding. Thus, the identification of two different concepts introduced the need to build two dependent variables: perceived quality of risk control and perceived value of ERM implementation. For example, in the annual reports of banks such as Royal Bank of Canada or Bank of Montreal (Annual Report 2009), the risk control strategies per risk have been shown.

  Risk control at the individual or enterprise level “should state that adequate processes exist for providing reliable risk control and to ensure compliance with local regulatory criteria” (Crouhy et al., 2001).

- Glantz (2003) refers to some of the plans and tools that financial institutions use: “To stay competitive, financial institutions must look to more sources of information and adapt sophisticated tools: cash flow computer modelling...” None of Glantz’s list items included anything related to people support for risk knowledge management or means related to collaboration or development of actions to work among RM groups. Similarly, according to Glantz (2003): “Financial Institutions succeed as long as the risks they assume are prudent and within defined parameters of portfolio objectives. This means policies and procedures must ensure that exposures are properly identified, monitored, and controlled...”

  Policies and procedures are management concepts that involve people and technology in order to achieve risk control and ERM, which are potentially related to KM actions. Additionally, Glantz (2003) states: “The most competitive institutions will implement the analytics and technology necessary to facilitate market-oriented portfolio management.”

- Ong (2006) indicates: “Risk exposures faced by companies are highly interdependent. The risk interdependencies represent one of the key rationales for ERM, and are why individual risks should not be isolated and managed solely by independent functions.” This suggests that there is a need to manage people interactions and processes according to the risk areas with a common orientation, in order to avoid lack of connection among risk functions.

  Additionally, Ong (2006) continues: “One of the key objectives of ERM is to provide consistent methodologies for risk quantification so that these risk concentrations can be measured and controlled across the enterprise.” He refers to: “A widely accepted principle in risk management is that any risk concentration can be dangerous.”

3.2. KM and RM processes

The KM concepts in the RM discussions are not explicit, but they are identified in the fact that people, processes and technology are interacting and require methodologies and validation of the RM actions. People concept refers to interaction, coordination and communication among employees in an organisation, in particular for the group of RM employees, and they are based on the actions in RM, risk control and ERM.

However, the specific variables mentioned in a general context are: communication among groups (Alavi and Leidner, 2001), work coordination in Robbins (1990), uses of technology for helping KM processes (Alavi and Leidner, 2001), uses of risk management information systems in general (Crouhy et al., 2001) that do not have clear specifications that include KM concepts or tools in an RM setting. The context examples show (Section 2.4) that these variables are important because of the experiences in losses and problems that have been based on people involvement.

Processes refer to KM processes and these were introduced in the previous chapter. KM and RM processes were identified and presented separately. risk control is a particular RM process and knowledge sharing is a KM process, but both can be related in the RM actions. The reason is that different groups and individuals are required to work together in order to solve RM issues and possibly require knowledge sharing to reach a solution. These issues can affect the whole financial institution in the bases of daily departmental work or in the need to communicate properly with the executives and the board in order to summarize the quality of the exposure of the financial institution.

KM processes, as were presented in the previous chapter, can be supported by technology, as can the RM processes. Both KM and RM processes can be affected by quality of data and the functionality of the solutions that the financial institution has. Some issues to solve for the technology application are: silos of RM work, the need for integration and the need to keep memories and shared answers in some of the activities that need to be accomplished. Integration of RM actions can be a point to build under similar data standards and reports, common data repositories and modelling processes, for example.

Sections 2.3.1, 2.3.2 and 2.3.3. brought about some of the questions to be analysed regarding the capacity of sharing knowledge, communication, work among groups and individuals, technology support and the value that KM could provide for financial institutions activities. Therefore, in terms of the research model, the hypotheses were formulated by taking into consideration the previous theory and experiences of failures in risk management processes. Moreover, this research is aligned, for the variable selection and hypotheses formulation, with what Alavi and Leidner (2001) introduced as research questions and the concepts about the KM processes adapted to the RM context. This is as follows:

- Knowledge is personalized and knowledge sharing has to be understandable by the users in order to be disseminated and to be applicable to different RM problems and actions. This leads to the search for understanding of the perceived quality of risk knowledge sharing (See Section 3.7.1).

- There is a difference between individual and collective knowledge, and at the same time there is a difference in terms of knowledge sharing among individuals, within and among groups, individuals and groups and with organisation as a whole. This leads to the need to ask about the communication among groups and the perception as individuals in the interaction and coordination of RM assignments and tasks (See Section 3.6.1).

- There is not a clear impact of IT in knowledge sharing; but there are tools applied and that can be used. There exist questions and doubts of what to use and what can be the most effective in getting a positive result of applying IT. This point leads to the search for the perception in terms of the technology use through a web channel, network capacity, and risk management information systems (See Section 3.8).

- There is contextual information that is important for knowledge understanding and assignment of meaning to information. This is related to the concept of providing capacity to the organisation in order to understand the results of RM processes and the possibility of communicating under the same terms and concepts. This point leads to the search for understanding about risk communication, value added to the information gathered, collaboration between individuals and the risk control and ERM benefits (See Section 3.6).

- Communication processes are required to guide the knowledge sharing. There are conditions of communication to understand, related to the source and the user in terms of knowledge sharing. Communication perception is based on the level of understanding of the messages that are transmitted and the means used. This leads to the search for the perception of quality communication and technological support for improving the shared work (See Section 3.6.2).

- The means for risk knowledge sharing can be formal and informal and the effectiveness varies according to the type of knowledge shared. The IT means for risk knowledge sharing need to be analysed in the way that IT can provide better support to risk knowledge sharing. This leads to asking for people and technology variables, people interaction and at the same time support for connectivity. Equally, the interactions are affected by possible individual limitations and the lack of willingness to participate in risk knowledge sharing initiatives (See Section 3.6.3).

- Intranets are a support for all KM processes and there are particular communication techniques and technologies to support risk knowledge sharing. This point led to the search for understanding of the possible relationships between technology and perceived quality of risk control and the ERM perceived value (See Section 3.7).

Based on the previous points and in the context of financial institutions, Peterson (2006) indicates that to have a financial institution, in particular banks, where every risk is mitigated and every loss compensated, employees sharing values with the same goal and managing compliance in a good way, is something not easy to achieve. The point is that ERM is converted into a corporate purpose that involves the executives and their responsibility, which includes people, processes and technology to support the RM processes in order to maximize the organisation's performance.

Peterson (2006) opens the KM doors when he refers to an interviewed person who said: "To know how much a bank is at risk, you don't just add up the risks, you have to synthesize the activities so that each risk is offset by another department's work." This means that there is a human contribution not only in the analysis of the individual risks but also in the coordination and capacity to add synergy and value to the organisation. The reason is that the integral view and the improvement of capabilities are required to support the financial institutions commitment of being sure that in terms of control nothing is missed.

3.3. Empirical observations of ERM implementation

From Table 3-1, the results of the surveys suggest the review of concepts regarding potential contribution that KM could have to risk control and ERM implementation. The points that led and support this research's hypotheses formulations are the following:

- The actuarial society survey focused on the gap of ERM training, but identified important points about the need for interdisciplinary work and the need for complementary knowledge.

- The Towers Perrin Survey identified the different levels of maturity in the ERM implementation. Equally, there is a clear indication that data, technology and process are the challenges, and mainly the issue of data quality, integration and availability.
- PriceWaterhouse presented the importance of the alignment of ERM strategy and governance even though there is a lot of room for improvement.
- Aon pointed out the need for integration of risk and finance information to be used in the decision-making process.
- RMA indicated issues in silo information systems development, issues in the language used in RM areas and a lack of understanding of ERM across the organisation.
- The Conference Board of Canada contributed identifying ERM benefits that can complement the benefits that have been used in this research.
- Ernst and Young indicated the need of improvement knowledge for RM processes that, each time, are more demanding.

Technical attributes of the survey	Knowledge points to remark
CAS (2001) 3021 questionnaires in 2001 were sent to the members of CAS Society and 298 answers were gathered. Respondents are people involved in the RM steps: brokers, agencies, actuaries, risk managers, financial analysts. All of them deal with different type of risks. This survey has a main purpose to identify the level of knowledge and understanding of ERM	• Knowledge about ERM was gained by self-study and self-initiative • Multidisciplinary work is required • Development of transferring and learning form experiences is required • There is lack of knowledge in several specific topics that includes ERM • Respondents consider it important to be more active in the risk integration process • Actuaries consider that they could use their knowledge not only in insurance industry but also other financial organisations • There is a desire to learn using different means to access knowledge • In terms of desired knowledge and required knowledge analysis identified what to look an educational program
Towers Perrin (2008). The survey included as respondents senior executives of risk and finance areas in the insurance industry around the world, 359 answers were gathered. The survey was online. The insurance industry was represented from casualty and property insurance companies, life insurance, reinsurance and other financial services	The main findings are: • There is a need to continue working on the ERM implementation; there is a lot of room for improvement • A company that is bigger has more ERM experience than the smaller size ones • European insurers are better prepared and the implementation has more steps done • ERM is influencing the making-decision process in terms of strategic decisions and risk appetite • The economical capital practice is evolving to analyse a full year • Operational risk is a weak part of ERM process a "significant work is required" • Data, people and systems were highlighted as challenges for ERM implementation • ERM has modified the decisions in different fields from pricing, product portfolio to capitalization
PriceWaterHouse (2008) Survey to insurance industry, 53 global insurers and reinsurers	• ERM is taking on more importance but there is room to integrate it with strategy • There are still issues with data and modelling • The governance over ERM is an issue • ERM is not yet well integrated with the business • Alignment of risk and finance is limited • There is a need to find better developments • Reporting through the ERM principles has improved • The analytic capacity has been improving and although there are more capabilities in scenario analysis and model building, there is still room to improve • A consistent risk language and alignment of risk and finance are required • Roles and responsibilities are not clear and interaction between risk and business groups is often limited
AON (2010) the survey with 210 responses from different industries around the world	• The board plays an important role to develop and include ERM in the organisation, including ERM in their strategy design • ERM culture is required to be engage and accountable at all levels of the organisation • Transparency in risk communication is needed • It is needed the Integration of operational and financial information into the decision-making process • It is required to use of methods to understand risk and added value • There is a need to be aware of emerging risk using internal and external data
Risk Management Association RMA (2006) ERM survey 31 organisations, online survey, all members of the association and directly involved in risk management activities	• Identified that the automation for the organisation in the silo view is better than integral one • A common risk language at the organisation is not good for a 25% of the respondents • The best terms understood are Loss given default, probability of default, risk thresholds and limits • The ERM knowledge is acquired mainly by the job, seminars, conferences, industry discussion groups • The three main barriers for ERM advances are: Speed of implementation, support from management, quality of data, staff and budget, lack of required data • There is mainly agreement that ERM helps in: strategic planning, risk appetite definition, more proactive culture of RM, better risk reporting, new products observed under ERM perspective, reduced capacity to train in ERM, and the concepts of ERM are not fully understood through the organisation
Conference Board of Canada, 87 executives in RM area were surveyed an**d** 44 answered	• Better understanding and management of risk (including integrated view) • Improved corporate governance or meet board requirements • Assist in allocation of resources • Effective decision-making • Minimize surprises • Improve risk reporting and risk controls • Achieve financial stability or better risk-adjusted returns • Improve credit rating • Compliance • Enhance shareholder or firm value • Create a risk aware culture • Best practices or achieve excellence • Support business or strategic plan
Ernst and Young 2001-2008 global survey	• Knowledge, from people, data and technology • ERM requires knowledge in identification, classification, transference, hedging, planning and evaluation of risk, the processes use tacit and explicit

Table 3-1 Surveys describing ERM practice and its development

In summary, the different surveys allow a review of several aspects of ERM implementation, perspectives, barriers and benefits, and open a window to do research in the influence of knowledge for ERM implementation. The hypotheses in general have been selected based on the literature review and the identification of the main ideas of the surveys that have been performed in financial institutions regarding ERM (see Table 3-1).

From the literature review and the surveys administered by different organisations, the variables and the items used to construct them are presented. Based on these variables, the next step was to formulate the hypotheses regarding the relationship between the KM variable and the RM variables; however, a point to take into consideration is that there is not a tested scale in previous research works to use in this research. This lack of previous studies using a scale has led to the need of using items to define the variables and to measure the reliability of the concept that has been constructed. Churchill (1979) identified the steps to build better measures. According to him the structure of the variable construction will improve when multi-items are used. In this research all the variables have five or more items to define the variable. The only exception is the variable people´s interaction for risk information system which has only one. The reason was that the variable captures the concept of acting with others to perform a specific activity, which does not indicate ambiguity or confusion.

The remaining sections are organised as follows: First, in sections 3.4 and 3.5 the variables that are related to RM are identified along with the items that have been used in order to consolidate the concept. Second, sections 3.6, 3.7, and 3.8 include the variables, items and hypothesis formulation regarding the KM concepts.

3.4. Perceived quality of risk control

The risk control actions are directly associated with the effect of failures in risk management; however, the use of KM processes in risk control is not clear. Bowling and Rieger (2005) present a concept they call the “Journey to Enterprise Risk Management.” In this concept, they identify how a financial institution is moving from a level of compliance to a second level of control, whereby the organisation uses the most common practices of review of actions and decisions. From these points, there is a need to move ahead to get a better understanding of risk management processes and to achieve ERM. Through these searches ERM is expected to develop a common language and orientation to perform risk reviews linked to the strategic decisions.

However, the journey supposes a learning curve and knowledge accumulation, but the ERM frameworks do not say anything about the proper use of the knowledge. The steps to get ERM include moving from the traditional risk control actions to something that has a holistic view. Thus in this study, the first point to review is what is happening with risk control and the KM variables. Or better, to identify if risk control is positively associated with KM variables such as collaboration, knowledge sharing and better people interactions.

Moreover, Matyjewicz and D'Arcangelo (2004) wrote referring to the value of using the Sarbanes–Oxley framework: "Senior executives learned the importance of establishing objectives, identifying risks that will prevent them from meeting those objectives and establishing controls that will mitigate those risks" and they said that an ERM solution can take two or three years to implement. From these points, the reflection is that the performance evaluation of the whole organisation takes into consideration risk as a factor that can change the results. This means a control of risk across the organisation might be a good enabler of the organisation's results.

From the interest of analysing and understanding risk control, a variable identified as perceived quality of risk control (*qrc*) was constructed. The items included for the variable construction are based on sections 2.2.3, 2.2.4 and the Abrams et al. (2007) main points. These points look for the optimization of the application of the policies in the organisation and search for the reduction of duplication of efforts. The variable perceived quality of risk control (*qrc*) was constructed based on the following 5 items:

- The risk mitigation tools are an essential piece of risk control. The section 2.2.3 introduced the RM processes and in addition to that literature, Pritchard (2001) refers to risk mitigation as the actions that reduce probabilities and the impact of risk, and this can involve many people. Crouhy et al. (2001) introduces the concept of risk monitoring as an essential way to manage limits of exposure and to make less severe the risk events. The risk monitoring needs to be performed by people who are not involved in the transactions and need the capacity to explain to management what is happening. In addition to these authors, Mun (2006) presents in his integrated risk analysis framework the concept of real options analysis which includes several people and areas across the organisation for developing solutions to mitigate risk threats according to the business environment. However, it is not clear how people perceive the risk mitigation actions in risk control. Thus, the item used was: *the risk mitigation tools are good*.

- The risk assessment process provides a means to measure and evaluate risk. This means the generation of risk control based on measurement and quantitative analytics capacity (Abrams et al., 2007) is identified as a priority. This is a movement from only qualitative level analysis to the quantitative approach. However, risk assessment is a combination of activities that includes value coming from qualitative and quantitative analysis. These actions are performed by people, and the organisation needs capacity to execute these actions regarding risk control. Thus, Lelyveld and Shilder (2003) analyse the financial conglomerates and compared silo or aggregated approaches to assess risk across the whole financial group. They showed the need for the involvement of many people and actions that are complementary to one another; in particular, risk assessment as a piece of risk control that requires people actions. However, the perception of the risk assessment process is not clear across the organisation. Therefore, the item used was: *the risk assessment process is good*.

- The risk transfer process is part of the protection for most of the assets. In terms of risk control, the traditional RM practise used to control risk transferring risk to insurance companies. Given the business of the financial institutions, many of their operations and products were not possible to insure and derivatives and other hedging strategies appeared. In terms of this research, it is valuable to identify the perception of risk transfer in a risk control activity. In particular, risk transfer includes equally the organisation's people as was identified by Pritchard (2001) saying that risk transference is an action that involves many stakeholders. The user, internal and external, of the services can be affected by risk transfer or, in terms of this research, possibly the knowledge of risk management people can affect risk transfer and then risk control. Then, the item used was: *the risk transfer process is good*.

• Risk control appears in the processes that the financial institutions already have. However, financial institutions have grown their basis of products offered to the market, increasing the number of products and developing new ways to offer services to the market. Financial products include a new risk exposure for the organisation once the product is in the market. Its evaluation is a way to protect the enterprise portfolio and to improve a risk control in a new area of risk exposure.

Products are created in order to provide solutions of credit, operations or investment to the customers, and in each field the product has risk to be calculated and to be aware of in order to protect the financial organisation of adverse events that can affect its final results. After Basel II and others of the frameworks (Section 2.2) the organisations were aware and oriented to avoid failures in the product releases. For example, a risk control action has to be developed to manage operational risk such as Panjer (2006) included in his review about operational risk. Panjer (2006) suggests the need of reviewing, analysing product standards, systems support and business disruption. All these points are associated with risk control. Thus, financial service products are connected by operations and technology and the control of them is the basis of the presence of the organisation in the market. There is not clarity enough about the perception of the risk of the products; therefore, the item used was: *the risk product evaluation is good*.

• Finally, risk control is evolving into the holistic view of risk and requires capacity to aggregate the analysis and the management options to act. The risk aggregation analysis represents the review of clusters of risk and exposure accumulation. Regarding this, Slywotzky and Drzik (2005) summarized the concept of strategic risk by indicating as a main point, the review of all the pieces of risk exposure under the same framework and organisation orientation. Nevertheless, the perception of the risk aggregation process is not clear. Then, the item used was: *the risk aggregation analysis is good*.

3.5. Perceived value of ERM implementation

In the previous section, the risk control construct is identified by five items and the review of the theory showed that financial institutions moved from a traditional risk control by silos to an integral view of risk across the organisation. To get to that point there are many steps to follow and one of the steps is to identify the possible benefits that an ERM program can bring to the organisation. Thus, this section is related to the work of different authors, particularly the work of Abrams et al. (2007).

The value of ERM is associated with two research circumstances. First, the risk management organisation in the current environment is based on risk types and the related areas have independent work groups. The review of operational benefits provides value given the possible different perception of a program that is across the organisation. Second, the operational benefits of ERM are not clearly identified with the same strength as the strategic benefits are. The reason is that, according to the previous chapter, the financial institutions are organizing their RM governance based on ERM principles, but the implementation is a work in progress. Probably the most important reason is that the operation of risk management, support and capacity of increasing interdisciplinary work, require the understanding of the people who are performing the basic work of risk measuring, assessment, control and support.

The competition in financial institutions is based on customer service developed under an integral view, which needs a risk aggregation analysis. Then, from the macro perspective, the purpose is to identify how the organisation uses ERM as an advantage to compete. ERM is expected to contribute to supporting the coordination of the financial institution offer based on the aggregated risk exposure that is accumulated in customers of the organisation. From the operational point of view, the aim is to identify which product definitions, trade-offs between risk and return and capital allocation represent actions that are improved by ERM implementation. ERM actions that need to be supported by people, risk management processes and risk information systems.

In measuring the value of ERM implementation, this research includes the position that this can only be answered by an individual, and not for an organisation. Because of the cost of ERM systems, it would be very difficult for an organisation to declare an ERM implementation as anything less than a complete success, especially in the current climate. However, anonymous individual RM practitioners can express their opinions more freely, and this is the basis on which the measures have been developed.

Based on the Abrams et al. (2007) reflection of the synergetic capacity benefit that requires a solid structure of information and quantitative capacity, the concentration, in this research, has been on Peterson's and Nocco's and Stultz's (2006) points of view (See for details section 2.2.5). These micro view points are bases on which to built risk management systems and alignment to connect the different RM silos as it was explained by Chrouhy et al. (2001). This means these benefits exist and are perceived as benefits because the ERM actions might support the implementation of risk management across the organisation in order to gain synergies.

Finally, Abrams et al. (2007) indicate that there are three critical characteristics of the ERM: developed integration, comprehensive and strategic. This idea complements the importance of the operational view of the ERM benefits if the purpose is to gain synergetic capacity in RM. The authors point out that data governance, policy simplification, standardization and optimization are part of the ERM design. In summary, there are components of ERM that are required to develop the desired synergy based on the better capacity in areas of people interactions, data, models and problem solving. In this research, there have been included items that describe benefits related to people, information management and specific capacity for problem solving. The variable perceived value of ERM implementation (*perm*) was constructed based on the following 9 items:

- The holistic view involves many people with a focus on the RM problem. Bowling and Lawrence (2005) expressed the view that all the stakeholders share a common interest that in particular is to monitor risk in order to reach a proper understanding of risk management. This has a meaning in the need of collaboration and sharing capacity among different risk management areas and development of governance. Or even better, as Matyjewicz and D'Arcangelo (2004) point out, more collaborative work is needed, and an ERM program needs to develop communication, knowledge sharing improvement and sharing of risk management values within the corporate culture. Although there is the need of some collaboration activities among people, it is not clear what the perception is from the members of the group. Hence, the item used was: *ERM improves collaboration*.

- Likewise, the understanding and improvement of collaboration is not enough. In ERM, a problem can require the solution and participation of various people from different RM areas. In particular, a problem that involves several risks needs more experience sharing for its solution. Matyjewicz and D'arcangelo (2004) describe that compliance needs to use experience from different areas in order to develop capacity for the integral understanding of risk, however what is not identified is the perception about the organisational promotion of risk knowledge sharing. Then the item used was: *ERM program promotes our experience sharing*.

- According to Oshri (2008): "By reusing knowledge, organisations may also avoid "reinventing the wheel" in terms of products, components, templates, and processes, thus freeing up resources to other core activities, be these customer responsiveness or innovation." The above point relates problem solving to experience. The experience is an aggregation of knowledge that can be used in RM problems. The silo culture in a financial institution can produce isolation of solutions that could be used in similar problems in other areas. An integral view allows discovering solutions to similar problems with the same tools; however, it is not clear if the organisations have the capacity to share the accumulated experience and know-how across the organisation to solve emergent problems.

  Waldvogel and Whelan (2008) point out that learning in risk management has to move ahead of basic risk business concepts towards the creation of "integrating risk awareness". They state: "Attaining this degree of risk knowledge requires innovative learning approaches drawn from technical communication, presentation, knowledge management and training..." Then, the item used was: *ERM reduces the number of times we reinvent the wheel*.

- The introduction to this section indicates the importance of data and information bases for the ERM program. The integration of risk analysis and control needs consistency and some common standards. Therefore, managing the same data repository implies more people reviewing data quality. Peterson (2006) identifies the need of data quality across the organisation as an important step for ERM; however, the perception of the possible data quality improvement is not known once an ERM program has started. Then, the item used was: *ERM improves the quality of data*.

- Now, the possible improvement in data quality is not only a component to determine ERM as beneficial to the organisation, but also is required to study people work given the need of analysing different risks simultaneously. Thus, the interdisciplinary and interdepartmental work is required given the dissemination of roles based on risk types and analysis actions. Bowling and Rieger (2005) remark that managers and employees need to think in a broad sense about how risk in their areas, functions, and departments affect what the overall company is looking to achieve. This shared work is more than communication; it is a joint problem solving process where the perception of the interdisciplinary work can be taken into account. Then, the item used was: *ERM improves our interdisciplinary work*.

- The concepts behind interdisciplinary and inter-departmental work go further than communication among groups. They include the capacity for problem solving that requires complementary knowledge; for example, the development of risk rating involves people's criteria that complement the outcome of Decision Support Systems. Thus, as Bowling and Rieger (2005) introduce the concept of the possible risk of interdepartmental work, in this research, a point to understand is the question of whether the ERM policies will contribute to developing the participation of different organisational areas in order to accomplish tasks. Then the item used was: *ERM improves our interdepartmental work*.

- Whalen and Samaddar (2003) indicate that: "Wise organisations manage and husband their knowledge resources in order to provide an environment for their members to make well-informed decisions and to take problem solving actions." Complementing the two previous points, the specific concept of mathematical modelling is included. This is selected because of the search for more quantitative support in RM, as was required by the regulation in the financial sector at the same time indicated by Abrams at al. (2007). Rao and Marie (2007) and Startiene and

Remeikiene (2007) talk about the risk management processes and the need for actions regarding the risk modelling process, and in particular, the quantitative modelling process. Then the item used was: *ERM program is expected to improve the capacity of mathematical risk modelling*.

- In the previous items, the possible risk knowledge sharing, integrity of data and multi and inter disciplinary work, were analysed; however, there was no review of a specific application of working together where people can share knowledge; for example, developing models. The modelling process in risk management requires assumptions and their validation, which come from external and internal sources, and from the business understanding and capacity to predict effects of the business environment. Similarly, creation and improvement of the models can come from experiences in different areas.

  ERM improves the understanding of model results (Startiene and Remeikiene, 2007). The stages of the risk analysis (Crouhy et al., 2001; Ong, 2006; Abrams et al., 2007) process include modelling, evaluation, estimation and verification. Therefore, the interest in modelling capacity and possibly the improvement because of the synergetic ERM approach, could be a value for the organisation. However, what is not clear is the perception of work in risk modelling. Then the item used was: *ERM improves our understanding of model results*.

- Modelling is a specific problem to solve, as was presented in the previous point. There are more problems to solve, such as the interpretation and application of ratings or analysis of exposure according to different segments of markets or products. Thus, Nocco and Stultz (2006) indicate that ERM is not an academic exercise, but a way to manage the strategy of the business based on risk management. This is a concept that illustrates how ERM is involved in the problem solution of business dimensions from a strategic view. Thus, there is not a clear perception of ERM contributing to the general problem solving process. Then, the item used was: *the integration of risk management view (ERM) improves our problem solving process*.

Furthermore, the search for relationships KM and ERM is based on the understanding of the participation of multiple areas and it is in agreement with Mitchell's work (2006) when he said that a: "...higher project performance was associated with knowledge transfer mechanisms that actively encouraged the exchange of information across organisational units and across organisational boundaries." Thus, in this section two dependent variables were introduced, as were the items used for constructing the meaning of these variables.

Sections 3,4 and 3.5 introduced the variables and items used to describe the perceived quality of risk control and the perceived value of ERM. The variables and items were selected based on the literature review of KM and RM, and the particular approaches of ERM surveys performed by different organisations. Additional literature that is specifically related to each item has been included in order to clarify its meaning and relationship to the variable that is being built.

The next sections bring the identification of the independent variables according to the items used and the formulation of the hypotheses (See Figure 3-1). These hypotheses have been formulated in order to determine relationships of the KM variables and the RM ones. The organisation points related to KM in this research are expressed through the review of the eight variables. Additionally, this research includes the three components: people, process and technology (Edwards, 2009) in order to categorize the hypotheses and to identify the KMS components as was indicated in section 2.3.5. Morgan and Liker (2006) used the concept of a socio-technical system including these three categories to represent product development as a system outcome. In this research it is aligned with the concept of KMS and considered a socio-technical system that could support the ERM implementation (See Section 2.3.5).

The basis of the KMS design will be supported by the relationships of the variables and the requirement that the literature has shown (Section 1.4). The KMS as a socio-technical system includes components from the people, process and technology variables that in this research will be analysed. The observation of a KMS as a competitive advantage (Halawi et al. 2007) opens the need to observe the KMS structure for RM in order to contribute to the system success supporting the organisational knowledge management processes and the achievement of improved knowledge and service quality perceptions, intention to use and user satisfaction looking to support and enhance the organisational processes of knowledge. Thus, in this research the Halawi et al. (2007) work is complemented with the understanding of the relationships between KM and RM variables that can contribute to supporting a better and successful KMS. This KMS is expected to be used as the support for RM processes.

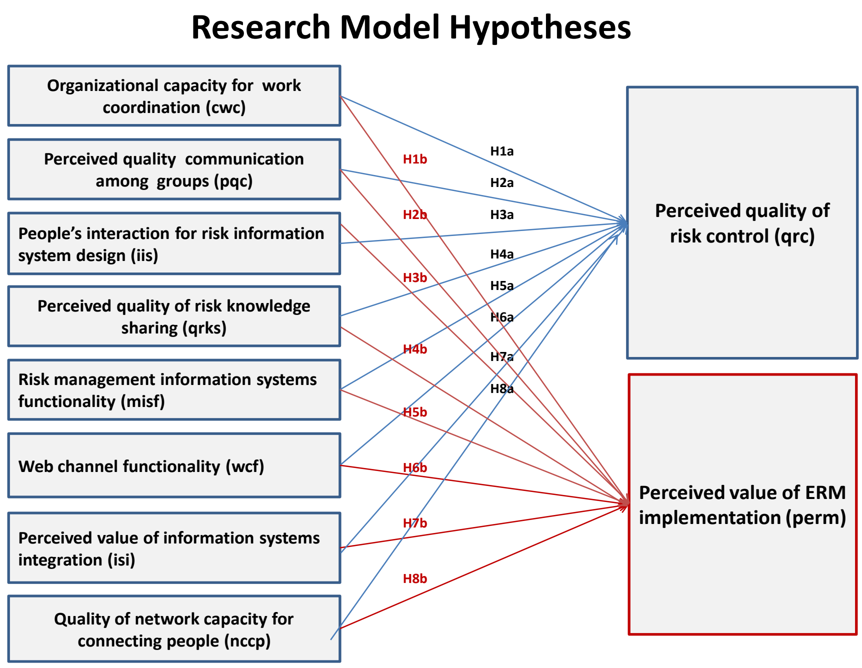

Figure 3-1 Research Model Hypotheses map

3.6. People hypotheses

Three hypotheses are formulated regarding people variables and they are presented in this section. These variables are: organisation capacity for work coordination, communication among groups, and people interaction in the risk information system design.

3.6.1. Organisational capacity for work coordination

This is the variable, in this research, that refers to the degree of involvement of the organisation in the KM processes. Fong (2006) indicates that “the advantage of adopting multidisciplinary project teams is that they are quicker in integrating the expert knowledge of different functions, for example, design, construction, marketing, maintenance, and accounting. Cross- functional project teams with mutual accountability and collective work products have been found to decrease development time and increase product quality.”

Organisational activities, project development and management practice put emphasis on the capacity for work coordination and it is becoming ever more complex to coordinate groups working on projects (Meredith and Mantel, 2003). There are more people with different backgrounds and specialties involved in projects, the skills and points of view of people are different and all these factors are part of the multidisciplinary and multi-group structures of projects. Work coordination refers to the assignment of responsibilities and accountabilities among the participants of a business initiative. In the RM context, the organisation has different people working in activities for areas and groups that have to be oriented to a common direction. This common direction is looking to achieve the goal of a proper organisation protection.

Hitt, Ireland and Hoskisson (2002) express the view that managers in organisations are evaluated for some abilities in the organisation and the capacity for identifying and using the core competences of the organisation. Managers have to deal with tangible and intangible resources; they have to manage the capacity to add value to different stakeholders. In general, managers have to deal with the coordination of employees in many different ways and to improve organisational capacity to transfer and use risk knowledge when employees are working on projects.

In addition, and as was mentioned in the previous chapter, the competitive advantage of the organisation can be limited because of the risk of potential losses caused by expansion, cultural pressures, reduced controls, communication of business values, learning systems and concentration on information (Simons, 1999). Moreover, business complexity and the cost of knowledge show the need to provide more meaning to the risk information and better KM (Sutcliffe and Weber, 2003) in order to build actionable answers to risk threats.

These previously stated views and the project complexity show the need for work coordination among risk areas, and it is not clear how the capacity for work coordination is associated with the improvement of risk control. Although organisational activities, project development and management practice are focused on the capacity for work coordination, this is not clear enough in the RM integral view. The need of coordination is a request to provide answer the business environment pressures on organisations and a way of using RM as a strategic discipline. The search for the strategic capacity using RM is looking to add value through learning, risk analysis and solutions as part of the day-to-day business. This strategic capacity is the basis for better business capabilities that preserve a better risk control (Meulbroek, 2002; Sharman, 2002; Liebenberg and Hoyt, 2003; Banham, 2004).

Equally, the capacity to use skills and talent in the development of strategy needs to have a mechanism to transfer and to share knowledge within groups, with different teams, or at the individual level with a work coordination capacity. Thus, the question for a good and coordinated use of talent in risk management environment is an open question and it is part of the interest in human resources research. The reason is that a good and efficient combination of talent can develop new knowledge and at the same time promote development of competitive advantages.

Therefore, organisation capacity for work coordination (*cwc*) appears when people who are involved in a process, project or assignment can achieve the goals with a synchronized development. The hypotheses selected were:

H1a: *Organisational capacity for work coordination is positively associated with the perceived quality of risk control.*

H1b: *Organisational capacity for work coordination is positively associated with the perceived value of ERM implementation.*

And the variable organisational capacity for work coordination (*cwc*) was constructed based on the following 6 items:

- Leidner, Alavi and Kayworth (2008) note: “Therefore, firms must engage in activities that seek to build, sustain, and leverage these intellectual resources.” This means the importance of supporting actions to improve intellectual capital. This capacity can be achieved with a better relationship among individual in an organisation as Hendriks (2008) notes: “There is a general recognition that relationships among individuals in collectives are centrally important in the organisational production of knowledge and its organisational embedding.”

  There are possible relationships and the organisation needs to coordinate people’s work. Work coordination ensures that people are not repeating the same task and are doing things that are not in a proper order. When a risk management group needs to work with others in order to produce a report, for example, the alignment and the same objective orientation of the work has to be a requirement to accomplish the result/task. One of the points is to develop projects that involve different people from various areas of the organisation. This variety of human resources working on a project can be seen in terms of the specialities and in terms of the areas where they belong.

  Zack (1999b) indicates that organisations provide value to tacit knowledge that is “augmented or shared via interpersonal interaction and social relationships. To build their intellectual capital, those organisations are utilizing “social capital” that develops from people interacting repeatedly over time.” This social capital is represented in actions that are part of projects.

  There are examples of projects that show the need to sponsor interdisciplinary work, and one of these is ERM as an enterprise-wide program. One of these examples refers to a KM project that requires, such as Samiotis et al. (2003) identify, coordination of the contributors, decision makers, HR and user-roles. This means that a KM project, similar to a ERM program, needs work done by people from different areas. Putting people from different areas to work together seems something easy to do, but as Parker (1994) notes, referring to the cross-functional work: “But like many good theories about group behaviour, when it gets tested in the field, barriers to its success emerge.” Parker (1994) identifies barriers of cross functional work and considers the “killer” barrier the lack of management support. As a result, two items about possible support and sponsorship of the organisation to this conjoint work were included in the research. The items used were: *the organisation encourages interdisciplinary work* and *the organisation encourages interdepartmental work*.

- Leseure and Brookes (2008) identify that: “In the research interviews, managers all agreed that their organisations could benefit from more collaboration at several levels.” This refers to ongoing projects, hierarchical levels or fields of specialization and supply chains. According to the previous point, one enabler is to have a sponsor for work across the organisation among groups and with different people profiles; another possibility is to have the organisations prepared for it. An example could be when people would like to have a meeting that includes a common objective. People need to be prepared with the same information and possibly the access to a common repository is limited. This can create a barrier for good work coordination. In terms of this example, Smith and McKeen (2006) indicate that the impact of IT in the work place is important because IT will provide flexibility. Flexibility can be related to tele-working, accessibility and collaboration among employees with a boundary-less environment.

  People need not only the willingness of the organisation for working on a project with different people’s profiles, but also the access to tools, rules, guiding principles and standards to facilitate the work interaction in order to solve business issues. Having access to web-based collaboration tools would be advantageous according to Smith and McKeen (2006) in order to support the enterprise work place. Then, the item used was: *there are good web-based collaboration tools*

- Research in KM has shown results where people can have barriers and motivators to share knowledge. Ribiere and Tuggle (2008) state: “In the presence of trusting culture, knowledge workers are more likely to use personalization tools in order to contact, assist, and share knowledge with their trusted co-workers.” Therefore, organisations can encourage the joint work from different areas, and it can be possible to access web tools, but the final decision of sharing knowledge is in the head of the owner of the knowledge. Then a point of interest is, if in a required work coordination environment, is it possible to have people open to working together with other people from different groups.

In solutions that support explicit knowledge codification like document management, there is a better understanding that these are not tactical but they are strategic (North et al., 2004). Document management is an example of the initiatives across the organisation that are used to develop a means for working with different people and areas, for instance: data-warehouses, corporate portals, CRM, and so on. However, it is necessary to determine if people want to work with other groups as is required in ERM processes, even when policies and means are provided from the financial institution. Thus, the item used was: *people are willing to work with multiple groups.*

- McNamara et al. (2002) indicate that managers are interested in cognitive frameworks and knowledge structures. They state that the knowledge structures are templates that organise knowledge and information which allows decisions in that environment. These structures can be represented by the general strategies used to interpret data from the business environment. The internal organisation can create some particular means to communicate under norms and standards. According to Buch (2008): "Both organisations and individuals are challenged to deal with continuing demands for flexibility. While companies are adopting their managing and organisational structures, demands on employees include continuous self-directed learning, adjusting to new work organisation, and changing job profiles."

In the above points, there is an identification of a potential coordinated work based on the organisation itself, people and tools. An element that is missing is the method, as well as, the rules and means to do it. The reason for requiring rules is the need to accept different styles of management and different behaviours of people when they are performing their work. Managing different groups that are working together includes some rules and means to use the organisational capacity.

Parker (1994) describes some of the factors affecting cross functional teams and some of them are related to, for example, boundary management, performance appraisals and goal ambiguity. The goal ambiguity refers to definitions that organisations need to clarify in order to sustain performance and achieve results of the working groups. Additionally, the explicit and documented knowledge needs solutions to access many different documents or team information. These solutions require definitions such as: naming conventions or definition of levels of authority to modify or access information. Thus, the item used was*: there are guiding principles for working with different groups.*

- The knowledge-based organisation is not just an organisation, such as a research centre or consulting company. Zack (2003) notes that this type of organisation "holds a knowledge-oriented image of itself. That is, it takes knowledge into account in every aspect of its operation and treats every activity as a potentially knowledge enhancing act." Financial institutions are knowledge intensive and could be considered knowledge-based organisations. Therefore need specific capabilities to achieve the goals, such as common means to work with different businesses, with different levels of knowledge, under the same organisation. Moreover, Files (2008) presents the evolution of collaborative work, which needs the definition of standards in the use of collaboration tools, indicating the expected changes that move from individual functions to multi-skills, multisite and multicultural rules of collaboration in intra-group work. For example, if a forum is open, some of the rules in terms of use have to be predefined, such as what kind of language is or not accepted and what kind of subject will be included. There are standards for using collaboration tools. Kubo et al. (2001) illustrated how in a Japanese bank some actions and rules in social networking were performed with success in order to improve work flow.

  Kubo et al. (2001) indicate that "given the life time employment practice at Michiko, members prefer not to be on bad terms with other in the bank." They add that even though with a high internal competition, the employees look for gaining "central positions in network of knowledge sharing by creating dependency relations." Equally, employees look for using informal times for improving the social network. However, they indicate there is less of an emphasis on technology because the Japanese market has to adopt the same infrastructure for all banks. This infrastructure that supports the network was not the main point to take care of; it was more about paying attention to people's attitudes and ways to manage relationships. Then, the item used was: *there are standards for using collaboration tools.*

The next section complements this one with respect to reviewing communication. This is because, on the one hand, the organisation can provide a means to coordinate work but, on the other hand, communication and interaction cannot be flowing or requiring actions that need more support.

3.6.2. Perceived quality of communication among people

Communication in the KM processes can play an important role, and a variable that takes this importance into consideration was built in this research. Te'eni (2006) brought to the analysis of communication its value as the basis for knowledge sharing. He states: "KM and communication go hand by hand. On the one hand, communication is the basis for knowledge sharing, which is a necessary component of successful knowledge management. On the other hand, knowledge is crucial for effective communication, and KM is therefore potentially central in facilitating communication." Te'eni continues by saying that the human interaction provides value to the knowledge management practice: "Clearly, some knowledge sharing involves close human-to-human interaction and cannot rely on automatic processes for storing and retrieving data via structured databases." Additionally, communication and KM are related: "KM is becoming a crucial element in the design and enhancement of organisational communication." Furthermore, as Te'eni states, there is an orientation to improving knowledge and from that communication: "Communication relies on knowledge regardless of its form and medium and KM will have to rise to the occasion."

Knowledge sharing and effective communication depend on the overlap and amalgamation of knowledge bases among people. Knowledge sharing requires more than IT; it requires the creation of a mechanism to share. This means that it takes into account the difference between knowledge sharing within and between groups. For example, the knowledge adapted to be communicated among individuals and groups (Alavi and Leidner, 2001). This knowledge sharing and its benefits are affected by (Uzzi and Lancaster, 2003) internal relationships. Moreover, Waldvogel and Whelan (2008) indicate that collaboration and communication support RM learning. In summary, knowledge sharing and communication could affect RM practice.

Lack of knowledge access, as well as reduced communication, can create failures or as Peterson (2006) notes, financial institutions have to create the culture that everyone is responsible for managing risk. For instance, the communication and understanding of the assumptions behind the decisions in hedging or investment are several and are key pieces of the decisions to introduce products, accept risk or to invest. The lack of risk knowledge sharing can create issues in the RM processes and the controls may not be enough. Weak means for communication can lead to insufficient knowledge of the operation, poor assessments, reduced use of the lessons learned, and poor understanding of the present and forecasts.

Knowledge sharing has an important influence on KM implementation because it provides connection between people and organisations producing dissemination, collaboration, innovation and acquisition of knowledge (Ipe, 2003). This means development of risk knowledge management capacity through understanding and analysis of experiences of KM processes, methods and technologies used in risk management problems. Some examples of the search for KM support in order to improve risk knowledge were presented in the introduction and section 2.5.

Communication among experts and people performing different activities could be a way to gain business value using the expert criteria and a proper information use. The flow of information and communication, which is a component of the RM work, can be interrupted if there is not a proper connection with experts that provide meaning to the information. Goovaerts et al. (1984) refers to the RM work in insurance that if only incomplete information is available, the actuary is the one who decides the principles and distributions to use. This means communication with experts can be fundamental to developing a program or to solving a problem given the influence on the interpretation and context analysis of the content. This is applicable to the analysis of market risk, operational risk, strategic risk, credit risk as well as actions of risk mitigation, risk transfer and risk capacity evaluation.

The flow of information for risk knowledge in an ERM context needs communication capacity among the different groups of risk management. A clear relationship between communication and risk knowledge sharing has not been identified. In this research, the search of the answer to whether there are such relationships or not led to the following hypotheses formulation:

H2a: The perceived quality of communication among people is positively associated with the perceived quality of risk control.
H2b: The perceived quality of communication among people is positively associated with the perceived value of ERM implementation.

The variable perceived quality of communication among people (*pqc*) was constructed based on the following 5 items:

- Te'eni (2006) concludes that: "Communication is the basis for knowledge sharing, which is a necessary component of successful knowledge management." This point, in the context of RM, means developing communication among the RM actors. Risk management processes are performed by different groups and they need to communicate with different stakeholders. The actions in different processes require the reporting and explanation of the results and figures within the report, and at the same time identification of the assumptions and conditions in which the analysis was performed. Uzzi and Lancaster (2003) studied how informal internal relationships affect the knowledge sharing and its benefits which opened the analysis of the quality of internal communication for creating these relationships. Equally, Lelyveld and Schilder (2003) point out that conglomerates require the construction of a common risk language for consistency and better management. This is part of the development of a better means to communicate among groups or individuals. Risk management groups require, in a financial institution, to take care of communication strategy. Therefore, the item used was: *the communication between the Risk Management groups is good.*

- Rollett (2003) expresses: "Without communication, there could be no knowledge management." This, in the context of this research, means the importance of identifying the level of communication in an RM group. It is one thing to have good communication among groups, which can depend on managers' relationships or organisation capabilities to support intra-departmental work. However, communication starts in the team to which the employee belongs. Every group has members that need to communicate and to share pieces of work. Effective teams require better communication and this is particular to risk management. Waldvogel and Whelan (2008) argue that good risk learning supports communication, collaboration and inter-business relationships. This is a complementary item to the previous one and the item used was: *the communication within my risk management group is good.*

- Zack (1999b) presents that the interchange of ideas and new solutions to problems provide capacity to the organisations. He indicates that: "Innovative knowledge is that knowledge that enables a firm to lead its industry and competitors and to significantly differentiate itself from its competitors." This suggests that to get new solutions in the RM context provides capacity for the whole financial institution. Besides, Eppler (2008) indicates possible barriers to an exchange of ideas can create barriers to problem solutions, such as integration of information, no conversation and knowledge sharing hostility, and possibly reduced experts access. Communication can be present in a good way among groups and within groups; however, there is a possible difference when communication is general, or it is oriented to solving a problem or to making decisions where different points of view are present.

  This research understands that one of the important steps in risk management problem solutions is to participate in discussions, exposing different points of view. Nocco and Stultz (2006) identify that a challenge in risk management is dealing with the centralized and decentralized decision making processes. They indicate that risk ownership is a part of the culture and the understanding of the same corporate objective. Thus, for ERM and risk control, what is required may be better communicative capacity in order to be able to solve more general problems or problems that are common to different areas in the financial institution. Thus, the item used was: *the communication environment fosters the interchange of different points of view.*

- Samoff and Stromquist (2001) highlight a point about the difference between information and knowledge that is related to the decision-making process in organisations. “Decision-makers have very short attention spans and they are unwilling or unlikely to read more than a few sentences on a topic. If so, for knowledge to be useful it must be presented succinctly.” This opens up the question about what is happening in meetings where the decisions generally take place. The understanding of a proper level of communication and the capacity to accept and support the different points of view can be a contributor for good ERM. However, even when there is good communication, when people are looking for answers or fixing steps in their actions, they need to develop road maps that guide them to conclusions for the shared work.

  Problem solutions require reaching conclusions and when many people are involved more effort is required in order to reach solutions; the dynamic of the solution search can be longer. Similar to the point above, Peterson (2006) indicates that the organisation needs to create a culture in which everyone is responsible for managing risk as a principle to lead the conjoint work. This means that there is a requirement of a proper environment and selection of means to make decisions based on risk when people interact in a problem solution. Then, the item used was: *there is a good capacity to get conclusions easily during meetings.*

- Uzzi and Lancaster (2003) indicate that the relationship and knowledge of the customer in a bank has influence on loan decisions because “learning, like knowledge transfer, is a function of the type of relationship that links actors.” These actors are from internal and external business environments. The question raised is whether internally in the financial institution, the links between teams are influencing risk management. Moreover, the interest in understanding a means to develop communication is part of the purpose of what Eppler (2008) expressed saying that communication can be improved using tools such as: “knowledge visualisation suites, dialogue techniques, knowledge elicitation methods.”

  Not only is the means required, but also there is a need to understand team work and the influence of communication within it. Organisations need people working together under different leaders, areas; teams are the cell of risk management processes. It was expressed by Argyris (1994) that leaders and subordinates demand better communication in order to think of the organisation as a whole and not just in their specific role. Furthermore, as mentioned by Peterson (2006), risk culture is related to developing the environment of working together for solving enterprise risk issues. These aspects point out the influence of communication in team work. Then the item used was: *the communication environment promotes team work.*

In the people group of hypotheses was included the review of the interaction of people developing a specific task the same as communication and work coordination concepts. However, there is room to understand how people perceive the interaction when a task is developed by different groups, and in particular, when the organisation is building a risk information management system.

3.6.3. Quality of people interactions for risk information system design

The organisational capacity based on people has a component that is tested when information systems are designed. The reason for this is that an information system requires interaction among different people, users and providers of information. Furthermore, Ericsson and Avdic (2005) state: "Acceptance of knowledge management systems is a function of perceived relevance, system accessibility, and management support." This means that the value of conjoint work for designing and developing systems is in providing solutions where the organisation is part of the conception and creation.

Referring to the approaches of KM and KMS, Earl (2001), through the KM schools, infers a KM strategy implementation model. This model has 6 steps. The first three relate to the vision of the company and its capacity to achieve goals based on the effective knowledge management. The other three steps relate to the implementation of the KM strategy itself. If the business knowledge vision is clear, the implementation steps can be reduced.

Equally, Earl (2001) identifies critical success factors for each school. These factors include, on the technocratic side, the capacity to keep content quality, sharing networks to connect people and learning capacity. From the economic school point of view, the critical factor relates to the capacity of an organisation to create specialist teams. From the behavioural point of view, the success factors relate to the capacity of the communication and organisational support to improve the knowledge sharing culture. This means that the organisation has to work on its definition of content to provide a means for knowledge sharing the same as to design a system under a collaborative environment that includes solutions for different RM needs.

The risk analysis tools and information structures supporting risk analysis and control have been independent of the organisational areas, with different views, specific objectives and processes. The independent treatment of risk has effects, such as a different language within the organisation to talk about risk, as well as, the fact that the expertise of the analysts has not been the same in different areas or applicable to different kinds of problems (Dickinson, 2001; Warren, 2002; Shaw 2005).

In particular, the design of an RMIS needs the review of requirements from different risk areas: people interaction from various areas, and the creation of collective risk knowledge which can contribute to the RMIS evolution into an ERMIS (Enterprise Risk Management Information System). Thus, based on Uchupalanan (2000), Majchrzak et al.(2005) and Clark et al.(2007) who express the value of collaboration to accomplish the information system (IS), facilitated learning management and support system design led to the hypotheses formulated as follows:

H3a: Perceived quality of people interactions in the ERMIS design is positively associated with the perceived quality of risk control.
H3b: Perceived quality of people interactions in the ERMIS design is positively associated with the perceived value of the ERM implementation.

The variable used was the quality of people interactions for risk information system design (variable label *iis*). This variable is only one item and its meaning is the level of people interaction in the ERMIS design.

In this section, three components of people attributes that can affect risk control and ERM were presented. The presentation includes a work coordination level that is complemented by the perception of communication and the capacity to interact performing a task in a risk management context. The next section introduces the process hypotheses: in fact only one, relating to risk knowledge sharing.

3.7. Process hypotheses

Risk management processes and KM processes were presented respectively, in sections 2.2.3 and 2.3.3, and according to that this research, they are concentrated on risk knowledge sharing as a potential contributor to risk control and ERM implementation. The following section shows the way risk knowledge sharing was built and the hypothesis formulated from it.

3.7.1. Perceived quality of risk knowledge sharing

The knowledge sharing concept was introduced in Chapter 2. In this section, the purpose is to show the items and the construct used in this research. Regarding this subject, a point to start with is related to problem solving and the motivation for sharing knowledge. Shariq and Vendelo (2006) state that: “When people solve complex problems, they bring knowledge and experience to the situation, and they engage in problem solving they create, use, and share tacit knowledge.” This is something to take into consideration in the RM environment because part of the problem-solving process is focused on complex situations before and after an adverse event appears. Solutions emerge and need, as King (2006a) points out, motivation of the solvers. “Economic, behavioural, and social factors must be considered when assessing the issue of how to motivate individuals to contribute their most valuable personally held knowledge to others who they may not even know, as in contributing to a KMS.” To this motivational factor influencing knowledge sharing, King (2006b) adds: “Knowledge transfer is done more efficiently when the knowledge to be transferred is relatively more explicit and relatively less tacit.”

Besides, based on Dickinson's (2001) concept of considering knowledge as a factor to reduce risk, it is possible to say in financial institutions that knowledge contributes to control, business strategy and underwriting processes. The reason is that risk protection depends on human actions, and most risks are impossible to transfer or to hedge. Then, the organisation needs to learn how to deal with non-transferrable risks, such as lack or loss of knowledge, and with risk minimization actions in the fields of legal actions, outsourcing and risk retention.

Knowledge sharing is a KM process. Improvement in knowledge sharing develops capacities inside the organisation. RM can be influenced by knowledge transfer attributes and signs, such as work satisfaction (See Section 2.5) and the capacity to share knowledge without a limitation on the number of people sharing. People find it easier to share explicit knowledge (almost by definition) and knowledge transfer is more internal than external (Dickinson 2001; Alavi and Leidner, 2001; Liao et al., 2004). Knowledge intensive industries, such as financial services, are often organised by projects, and trust and professional rules are fundamental for the development of projects (Schamp et al., 2004). Additionally, head-offices have to be more effective and efficient in knowledge sharing given the high value of the branch office today; they provide advice and support for transactions, investment and acquisition of new products such as insurance or credit (Moore, 2006).

Knowledge sharing can be adversely influenced by organisational silos, and business units can require assistance in knowing how to transfer their practical experiences (Horton-Bentley, 2006). For the experience transfer it is necessary to take into consideration that the low speed of change can reduce the value of experience in some specific fields (Hayward, 2002). However, it seems that independent intranets, with a large emphasis on IT for knowledge sharing and KM processes based on networked IT systems, reduce knowledge sharing (Swan et al., 1999).

Knowledge, experience and feedback in an organisation have a flow in both directions: top-down and bottom-up. The hierarchical relationship among data, information and knowledge can be analysed; however, the core of the analysis is indeed in the identification of knowledge with information processed by individuals This means that knowledge sharing requires more than IT; it requires the creation of a means to share.

As mentioned in section 3.6.2, knowledge sharing and effective communication depend on knowledge bases among and between people. IT is considered a tool for providing knowledge amalgamation and knowledge classification, which are bases for a KMS design and for contextual information analysis. Knowledge sharing can be a KM process allowing the improvement of the definition and organisation of risk knowledge use in ERM implementation. The implementation of ERM is a dynamic process and the new ways of risk control identify new risks to analyse.

Moreover, Ong (2006) identifies challenges and issues that provide insights into a KMS design. Some of these issues are: lack of buy-in from the board, unattractive and inconsistent measurement and reporting, redundancies and gaps across risk functions, insufficient human resources, systems, data resources, and failure to clearly demonstrate early positive results. Therefore, ERM implementation can require a proper risk knowledge sharing in each step to deliver adequate integration of the integral risk understanding.

The ER can be seen differently whether market risks and corporate objectives are aligned or not**.** Bock et al. (2005) identify that: "Individuals' knowledge does not transform easily into organisational knowledge even with the implementation of knowledge repositories." This opens an interesting set of questions about the knowledge sharing behaviours particular to the RM environment, where "employees' personal belief structures" and "institutional structures" are in place. ERM has to deal with complex problems in the implementation, such as the evaluation of the integral risk severity or risk level analyses in a financial institution (Lam, 2003). This is especially true in the decision-making process of transferring and hedging. There is a lack of clarity as to the reason for identifying risks, extension, scope and metrics in the context of risk.

Accordingly, risk control and ERM implementation can require risk knowledge sharing in each step of proper integration of the ER analysis. The hypotheses formulated were:

H4a: The perceived quality of risk knowledge sharing is positively associated with the perceived quality of risk control.
H4b: The perceived quality of risk knowledge sharing is positively associated with the perceived value of the ERM implementation.

The variable perceived quality of risk knowledge sharing (*qrks*) was constructed based on the following 5 items:

• In the previous section, it was indicated that people willingness to communicate or to interact is part of the improvement of the actions in RM. It has been mentioned that there are barriers to knowledge sharing. As Teigland and Wasko (2008) point out, there is a way to deal with these barriers: "As a result, participation in inter-organisational networks leads to knowledge leaking in at the same time as it leaks out of the firm." This point can be complemented indicating that a better flow is given by a better relationship among individuals who possess a common practice, such as Smatt and Wasco (2008) expressed: "When individuals have a common practice, knowledge more readily flows horizontally across that practice, creating informal social networks to support knowledge exchange."

Similarly, people may or may not be willing to share knowledge. The importance of the willingness of knowledge sharing in a financial institution was identified by Liao et al (2004). Furthermore, Holsapple (2003) shows knowledge externalization as a means to produce organisational outputs that can be associated with competitiveness. This means that risk knowledge sharing can be a component that takes into account the improvement of the RM practice. However, there are barriers to knowledge sharing as well as factors that enable knowledge sharing, such as a good work environment and organisational trust (Wang et al. 2006). These barriers and enablers are embedded in the work actions and the people's perception can introduce an element of understanding of risk knowledge use. Then, the item used was: *people are willing to share risk knowledge.*

• Corral et al. (2008) refer to documents saying: "Paper documents such as memos, white papers,….were filed based on the value of some specific field." To find documents people needed to know the value of the field that was used; "Document management systems require more structure." This structure being important because as Corral et al. (2008) say there is transition in documents: "Several factors have contributed to the shift from paper to electronic documents." Financial institutions use more and more electronic documents, but unfortunately, the organisations do not provide, in general, guidelines to store and retrieve digital documents. This lack of standards creates a gap in the capacity to retrieve documents that are stored.

As was said in the previous point, people could show willingness to share but what about the organisation capacity and environment to share knowledge. One way to organise the sharing of knowledge is through documentation of the knowledge that is possible to codify. A lot of work needs to be documented for sharing knowledge. North et al. (2004) identify document management as an important process in strategic information management. Documents are part of the explicit knowledge and as Alavi and Leidner (2001) express, it is easy for individuals to transfer their explicit component of knowledge. Thus, the item used was: *the documentation is good*.

• In terms of communication, one thing is to get the willingness of people to share. It is another to have good documentation, but the access to what is not documented or to the experiences of people in the organisation may be not clear enough. O'Dell and Grayson (2003) point out: "We believe most people have a natural desire to learn, to share what they know, and to make things better. This natural desire is thwarted by a variety of logistical, structural, and cultural hurdles and deterrents we erect in our organisations."

Besides, Jasimuddin et al. (2008) indicate that preserving knowledge is valuable; the organisation can keep memories in documents, for example, but to share this knowledge can be an issue to solve. Some organisations have overcome some of the barriers of knowledge sharing. In the financial market, Lincoln Re (Zack, 1999b) competes "via the high quality of its knowledge about particular classes of medical risk"; knowledge that is coming from different areas of the organisation and is documented to create the competitive advantage.

As was identified in section 2.3, not all knowledge is possible to document or to codify. This means that the capacity for developing a means to share tacit knowledge is a possible management purpose. In risk management, the experience is crucial to improve the practice of risk assessment and to provide meaning to the outcome of models and reports. Wenger and Snyder (2000) note that using communities of practice experience can be transferred to other interested people. Similarly, Waldvogel and Whelan (2008) indicate that learning and communication require different and innovative approaches, possibly the experience from other members of risk management teams. In financial institutions, particularly, in the risk management groups the connection and access to experience can be part of risk knowledge sharing process. Thus, the item used was: *the access to the experience of others is good*.

• Eppler (2008) indicates that knowledge communication is associated with interactive and collaborative style, and indicates some of the methods that require an "open atmosphere" for different points of view. Now, people could be willing to share and the means for that exists, but the question is what is happening in the practice when different departments and people are working together? In that situation, everyone can have a piece of knowledge of the risk management problem to solve. People need to review and to learn from the results, and for that they require spaces to share. King (2006) notes that some organisations motivate knowledge sharing. This happens when management and organisational support contribute to the knowledge sharing process. One of these organisational components is given by the departments, and in particular for ERM, it is important to see if risk departments have a guide to move in a knowledge sharing direction. Therefore, the item used was: *the environment to discuss results interdepartmentally is good.*

• Finally, Eppler (2008) points out that in communication there can appear issues when experts are communicating about experiences or errors. These barriers are related to interpersonal and professional influence. The organisation in RM can be already prepared for risk knowledge sharing, and the ingredient that is required is to find a problem that needs the creation of a conjoint solution. In some cases in risk management problems, particularly in ERM, a solution requires more people working together (Beasley and Frigo, 2007). One of the risk management processes is modelling, which in general, includes many of the skills and resources that a RM organisation has. The reason is that the developed solutions could be applicable to different groups and that are using the pieces of knowledge from different risk groups. Then, the item used was: *there is an appropriate environment for the creation of shared solutions.*

Once the people and process variables have been reviewed, the following step is the understanding of the technology impact in the KM processes for ERM and risk control. The next section includes the hypotheses referring to technology from the perspective of the risk management information system functionality. It also refers to the support that the web based solutions can have in the RM organisation in order to support risk knowledge sharing and contribute to the development of risk control and ERM value.

3.8. Technology hypotheses

The previous sections have presented the concepts and hypotheses related to people and processes. In this section, the technology hypotheses are introduced. The technology approach in this research includes four ways of concept analysis based on the literature review. This review identified the need for the information systems and support related to the diversity of the risk management activities; activities that require coordination and shared resources. Thus, the variables used were: risk management information systems functionality, the web channel functionality, the capacity to integrate the information systems, and the network capacity to connect people at the organisation.

3.8.1. Risk management information systems functionality

Section 2.2.6 identified a group of attributes that the risk management information system should have. Functional capacity is one of the required attributes. This concept includes the capacity to answer the needs of the users and the way to provide adequate service to the processes. Functionality of information systems is an attribute that organisations as a whole and users look for in order to perform their activities. According to the demands of regulatory frameworks in RM and bases for the IT strategy in the financial institutions there are multiple needs to satisfy in the design of the risk information system, such as: support to the risk modelling process, development of experience in risk analysis, management support, improvement of work flow, and capacity to work with multiple groups in a project (Dinner and Kolber, 2005).

In general, the information systems design needs to deal with the integration of information systems and how to achieve goals of compliance with the new market conditions. There are many difficult and complex tasks to perform in order to follow regulations, and technology should support them. These tasks include (Crouhy et al., 2001) transformation of processes and data; control, maintenance, design of the information and technology architecture; reports; and the ways to adapt the organisation to new conditions. These tasks, changes, modifications in some of the processes and the need to integrate are related to the demand for activities oriented to provide transparency, governance, accuracy, accountability and integral reports.

There are four main requirements to implement a risk management information system (RMIS): First, management of the project cost and competing priorities (Levine, 2004). Second, technological attributes, such as a flexible architecture, data model and risk measurement capability. Third, an overall view of different factors and controls more than solutions in individual sections of risk. Fourth, data management, structure of documents and reports, and data mining in knowledge discovery needs to be performed (Hormozi, 2004). These requirements show that a wide spectrum of functional attributes for a RMIS is required, and its capacity to support risk knowledge sharing among different areas can be affected.

The compliance process for financial institutions includes changes in the business process and systems in particular in the RMIS. Peterson (2006) points out: "Implementing an ERM program can change the way everyone does their jobs." Compliance means to review everything that the organisation is doing in order to achieve the goals under the regulatory constraints.

The systems provide capacity to work with multiple groups on a project (Smith and McKeen, 2006). A RMIS is much more than just another accounting system, as was indicated in section 2.2.6. The system should provide: reporting capacity under accounting principles, help to manage and understand operations and products, help to create capacity to review potential losses, causes of risk and help to measure risks related to different exposures. In summary, Chrouhy et al (2001) point out that: "An effective risk management system needs to be able to generate the necessary RM information on all risks, perform specific analytical functions, and permit multitasking." They state: "Many risks arise from the fact that today's banks are engaged in a range of activities. They trade all types of cash instruments, as well as derivatives…either for their own account or to facilitate customer transactions." The reflection on this quote is that the information systems for risk control and ERM need to deal with multiple products, multiple users, various needs, many organisational roles, etc. All these various states are considered part of one organisation.

The design of the RMIS, its architecture, technology and modelling developments all contribute to ERM implementation (Klefner et al., 2003). In particular in RM, there are areas of concentration for RMIS. According to Apte et al. (2002), the problem is not just to describe what the organisation needs or the request; it is to predict, to optimize and to classify risks. This means knowledge production, improvement of the attributes and overcoming the issues of the RMIS design. For example, in actuarial science there is a process of building statistical models which describe the claims behaviour, create different policies and adjust models according to contract clauses of the products and their potential claim development.

The required attributes of RMIS comprise technology for integration and the way to address the solutions to gathering data in a proper data architecture that allows analytics capabilities and sharing options. Even with the clarity of the required capacities, it is not clear how the design of the KMS integrates and connects people actions, network and risk knowledge capacity. According to the aim of this research, the study involves the search for perceptions about reporting, internet and intranet use, delivery means to multiple tasks, collection, normalization, analytics, and sharing knowledge distribution in order to realize the practice of the RMIS and relationships to a KMS. Particularly, the functionality of a risk management information system can have influence on risk control and ERM. Functionality is identified as the capacity that the system has for answering the needs of the user (O'Brien, 1996). The following hypotheses were formulated:

H5a: The risk management information system functionality is positively associated with the perceived quality of risk control.

H5b: The risk management information system functionality is positively associated with the perceived value of ERM implementation.

The variable risk management Information systems functionality (*misf*) was constructed based on the following 5 items:

- Pan and Scarbrough (1999) indicate that the emphasis of the literature in KM has been in "the conversion of tacit knowledge into an explicit form through the use of information technology." However, they point out that because of different kinds of tacitness in knowledge, there is a need for a socio-technical approach to support business actions. In particular, in the RM practice, development of products and analytical tools is based on tacit knowledge, and the question is how to support these activities from a technological point of view.

  The functionality of the risk management information system covers many specific steps from data management to report creation. One of the steps that comprises part of RM practice is the risk management modelling support. Users of the risk management systems need to develop models for risk assessment, product valuations, etc. Levine (2004) identifies an important point with regard to the modelling process that, is for example, the use and inclusion of big amounts of data and a big computation capacity. This was complemented by Smith and Mckeen (2006) who point out the trend of moving from a strategy mobilization to a strategy collaboration for information systems. This trend shows a step forward after data management within the organisations. Thus, in particular, modelling in an ERM strategy could require system support in data management at the same time as providing calculation capacity and collaboration among different experts in a risk type or in a specific kind of problem. Then, the item used was*: the systems provide support to the risk modelling process*.

- Malhotra (2003) exposes the issues with data when actions across the organisations have been performed. Previously in Table 3-1, it was shown how data creates issues in ERM implementation. "Integration of data and processes across inter-enterprise value networks will also impose certain challenges of organisational control." Malhotra

(2003) continues by saying that a concept to take into consideration is the one associated with maintenance and improvement of the systems; "KMS designers must take a holistic approach to designing inter- and intra-organisational "systems" with due consideration not only for the technological design, but also for the design of strategic sustainability of these systems." Sustainability that can be in the RM environment to get access to what people are looking for; for instance. expertise.

In the point above, risk modelling was introduced as a functionality request of the system and part of the point was how to develop collaboration among RM experts. Similar to risk measurement, risk analysis requires a lot of input from experience. Crouhy et al. (2001) identify the bases of the risk management information system and point out the importance of managing risk independently of the risk taker experiences only. They suggest the need to learn from the best practices. Rao and Marie (2007) identify the experience in a market as an example of the practice that is required for reducing the mis-management of risk. The main point is the differentiation of managing risks that have external causes and risks that have internal causes. Both cases need a learning process and demonstrate how experiences are input for decisions and efforts orientation. Therefore, the item used was: *the systems provide access to experience in risk analysis.*

- Neef (1999) expresses the view that technology has helped to connect people in different organisations, different locations. "New groupware technologies, browsers and powerful search databases...in order to capture, organise and transfer information and knowledge, organisations, need to take advantage of the new computing and telecommunications technology." From this comment, the question is if in RM practice there are good means to access shared sources of data and information. RM includes data from the market, operations and the economic and business environment that are created based on new knowledge introduced when risk analysis is performed. Data is the input for risk measuring and the risk management process; storage, access and possibility of using them are needed in order to support decisions and for this different means can be used; one could be the web based system.

The data quality, accessibility, standardization and architecture are musts for managing risk. The outcome of the analysis is the creation of new data that has to be properly managed in order to provide the bases of risk measurements. (Crouhy et al. 2001;Levine 2004; Rao and Marie 2007) The perception of RM people of how is the capacity of the financial institutions for supporting data management is not clear. Given the variety of activities in risk measurement for different kinds of risks, the data management could require effort to provide the right answer to different users in RM. Then the item used was: *the systems provide adequate data management support*.

- Lay and Chu (2002) studied some organisations and analysed their knowledge architectures. In their analysis they indicate that the organisations developed knowledge structures that supported the work flow and the capacity of the organisation to generate value. The question that emerges is whether the information systems in the RM environment are supporting activities that can speed up RM processes. Data are pieces of the risk management system that need the capacity of the system for transforming them into information, RM work and task executions. Given the several areas involved and the interaction with different people, there is a need to develop capacity to produce a smoother chain of tasks. The support for flexibility in qualitative and quantitative analysis when many various areas are working together is required.

  There are actions that require more than raw data and, in particular, actions in the RM areas. Functionality is associated with the capacity to provide solutions to the users and to create value in the RM group; value that can provide the advantages of reaching the integral view in RM (Abrams et al., 2007). The value of an integral view of RM is related to information gathering and management, access, and report sharing used to achieve final results. However, the question is whether the information system supports these purposes. The item used was: *the systems provide capacity to improve work flow.*

- Nonaka (1994) expresses the view that team work provides capabilities to the KM processes and business processes: “For example innovation, which is a key form of organisational knowledge creation, cannot be explained sufficiently in terms of information processing or problem solving." Furthermore, "[t]he span of team activities need not be confined to the narrow boundary of the organisation... In sum, the cross-functional team in which experience sharing and continuous dialogue are facilitated by the management of interaction rhythms serves as the basic building block for structuring the organisation knowledge creation process." The point here is whether the organisation is supported by systems to develop capacity from team interactions in order to accomplish projects.

Besides the above points, the risk management system functionality could provide support to the intra-groups in the RM areas. Interaction among people requires more than willingness to work together. Smith and McKeen (2006) indicates that the information systems will focus on managing solutions more than on assembly. This means developing users and support using different options that may or may not include web based capacities. Working in a multidisciplinary project needs participation and support in many ways, as was presented in section 2.3.2. Communication capacity is an item to take into consideration, but another is the understanding of the capacity of the risk management system to support those multiple actions. Then the item used was: *the systems provide capacity to work with multiple groups on a project.*

Now, the risk management information system functionality supports many of the needs of the RM user; however, there are tools and means in KM systems that can be used based on the web channel and that need structure in the organisation. In the next section, the variable used refers to the web channel functionality according to the perception of RM employees.

3.8.2. Web channel functionality

The interest of this research in discovering the KM and RM relationships includes the means for sharing knowledge. One of these means can be the use of the web channel. The construct that this section refers to is the capacity that the organisation has for using intranets to support the financial institution. Zhang (2005) indicates that KM can be gaining support with web technology and potentially an RM application can be improved.

He states: “The web technologies are not only changing the landscape of competition and the ways of doing business but also the ways of organizing, distributing, and retrieving information. Web-based technology is making effective knowledge management a reality, and web-based knowledge management systems have been developed and deployed.”

To complement Zhang’s point of view, Jennex (2006) expresses the idea that the web capacity can be used for an integrated technical infrastructure which includes networks, databases/repositories, computers, software and KMS experts. He argues that for getting these components there is a need in the organisation of:

- A knowledge strategy
- A common enterprise–wide knowledge structure
- Motivation and commitment of users
- An organisational culture that supports learning
- Senior management support
- Measures established to assess the impacts
- A clear goal
- A learning organisation
- Easy knowledge use
- Work processes designed to incorporate knowledge capture and use
- The security/protection of knowledge

The above points indicate that for the KM processes and KM implementation requirements of a KMS, it can be useful to have an IT support of the integration of knowledge to directives, organisational routines and self-contained task teams. The KMS (Alavi and Leidner, 2001) is based on the subsystems of technology and organisation, as was presented before. The KMS is not just technology oriented; it has to include the social and cultural components of KM (Davenport and Prusak ,1998; Malhotra, 1999).

In 2003, Bruner et al. introduced the Internet as a way to develop virtual communities, cross company teams, collaborative actions, and the capacity to support business processes in a different way. Many of the possible failures with users relate to the web design and the way of generating interactions. In addition, Liebowitz (2006) opines that personalized communication, person to person, is preferred to the search using engines like Google. Organisations have different levels of structure and at the same time phases of evolution that affect the means and the purposes of these means in the organisation. The means are related to people, processes and technology that are aligned to achieve goals. In particular, for knowledge sharing, the KMS has different means of support. For example, in banking at the World Bank, communities of practice are used (Wenger 2000). However, the communication capacity of the organisation can influence risk knowledge sharing in the activities that RM employees perform. In particular, ERM communication is influenced, as was mentioned in section 2.2.5. and 2.4., by the difficulties of language spoken as well as expertise application to solving different problems (Dickinson, 2001; Warren, 2005; Shaw, 2005). The quality of the knowledge sharing channels is affected by the organisation, the method, and the informality.

One potential knowledge sharing channel is the web channel used in order to improve the communication capacity. The organisation areas need to be more effective and efficient in knowledge sharing given the variety of distribution channels of the services (Moore, 2006) and the influence of banking silos and the business units (Horton-Bentley, 2006). Financial institutions, as was presented in section 2.1, have different technologies and service means to deliver their services to their customers. There are branch offices, ATMs, specialized offices for some specific segments of customers, web channel based banking, telephone banking, etc. The diversity of the channels implies different capabilities in terms of technology and people, and all of the possible options oriented to provide integral solutions to customers.

However, it seems that having independent intranets, putting a lot of emphasis on IT for knowledge sharing and having a reduced flow of KM processes through network systems reduce knowledge sharing (Swan et al., 1999). The search for risk knowledge is not effective if there is a high volume of knowledge available (Alavi and Leidner, 2001) and if the web search tools, crucial in ERM (Simoneou, 2006), are not providing good results. Thus, the influence of the web channel functionality could affect the risk knowledge sharing dynamic.

One of the important aspects of the web channel is developing a good functionality in order to provide user satisfaction and traffic. Some of the features that the web channel could have are: access to collaboration tools, access to applications of risk management, access to the proper data, appropriate interaction, problem solving, support communication, and support risk management controls, etc. Kalakota and Robinson (1999) complement the above points by pointing out that in the transition from e-commerce to e-business, technology is not only for creating products, it is also useful to enhance the experience with the product. This experience is related to the speed of service, self-service, integration, customization, management of applications, multichannel integration, and quality of network and collaboration.

The question is about the contribution of ERM to the organisation and the use of the web channel support to connect people, to support the access to data, processes, applications and in general to the generation of consistency in all the dimensions of risk across the organisation. Then the hypotheses formulated were:

H6a: The web channel functionality is positively associated with the perceived quality of risk control.
H6b: The web channel functionality is positively associated with the perceived value of ERM implementation.

The variable web channel functionality (*wcf*) was constructed based on the following 6 items:

- Shen and Tsai (2008) express the opinion that investment in IT can help in KM: "Furthermore, findings in this study also reveal that emphases on investment in IT and support from executives have the potential to improve the efficiency and favourability in implementation of KM." This support of IT can be focused on different areas, but Rollett (2003) indicates that according to the collaboration technology there is a better contribution to creating and transferring knowledge generating integration and maintenance capacity.

This item refers specifically to the intranet as a resource that the financial institution has as a first source for the user connectivity to others. Watson and Fenner (2000) point out that an issue in many companies has been the development of the isolated deployment of intranet projects. This means that because of having many different groups with various tools that in RM work together is needed to understand how the RM intranet is coping with the user expectations. Expectations related to the management of the desegregation of risk knowledge that is not accessible by other groups. Thus, the item used was: *the risk management Intranet provides access to collaboration tools.*

- Maier and Hadrich (2008) indicate the multiple access services in the organisation, from personal services to applications, data in different repositories, people interaction, collaboration, learning, and experiences. Once the intranet is providing the basis of support to the different RM groups, an additional step is needed to identify the level of content that is required and supported by the issuers and users. One kind of intranet service is access to different applications and gaining efficiency of connectivity. People go through different systems to perform their work and one stop shopping can be efficient and effective. The content management system is supported by web services to make the business processes accessible (Leyman et al., 2002). For applications and content access, the enterprise content management tools can support activities among groups (Smith and McKeen, 2003) and it simplifies work processes. The point to identify is whether the intranet is providing the access to what the user needs. Then the item used was: *the risk management intranet provides access to all applications used in risk management*.

- According to Tseng and Lin (2008), related to data, information and knowledge repositories: "Information and knowledge of a project can then be identified as project components in the project management and preserved in a Web-based system that provides the platform for the exchange and storage of information and knowledge." This indicates that, in addition to the previous points, the intranet can support access to data. In data architecture, the access to them can be something independent from the web channel. Some of the data warehouses provide their own portals or interfaces to access data. Access to consistent and accurate data requires similar standards and users reviewing and improving repositories; and in most of the cases, people from different RM areas are using them.

In 2001, Samoff and Stomquist state that the creation of knowledge data bases was problematic for the processes of the various organisations contributing to the aid agencies that deal with risk management. In risk management, the contribution to data repositories (Levine, 2004) is from different areas, and sharing the risk data and information can provide benefits if the data is possible to manage under similar standards. The access to data in general needs clear identification of the access process because the data that is created, input and kept based on many sources: transactions, customers, products etc. The adequate data for performing different tasks in RM is complex given the level of aggregation required, or the segmentation in multiple dimensions. However, the question is whether there are means to access these repositories where people can get the data in the way that is needed. Therefore, the item used was: *the risk management Intranet provides access to the proper data*.

- Holsapple and Jones (2008) refer to the possible development of capacities that the organisations can have based on knowledge: "An organisation should recognize that its KM strategy can be connected not only to its knowledge assets, but also to its knowledge processing capabilities." This indicates that data can be accessible, but additionally, the option to work with different people is required and the intranet could support it. Solving problems that affect different areas and compromise the exposure of the financial institution can require tools for facilitating a conjoint work. One of the needs of the risk management professionals is interaction for solving problems and in particular, when many of the actions are based on assumptions that need to be validated and aligned across the organisation. The question is whether the intranet can support and help this interaction and development of governance capacity (Bowling and Rieger, 2005). Then the item used was: *the risk management Intranet facilitates interaction in the problem solving process.*

- Nonaka (1991) indicates: "A company is not a machine but a living organism" and managers are the suppliers of conceptual frameworks to employees in order to use the experience. This is a topic of communication and a topic of means to connect managers with employees. One means can be the intranets. Data can be accessible and the conditions for interaction provided; however, people might not be attracted to use data or to give a good use of data. In the ERM work and risk control, better communication and the possible review of methods, controls and policies can support the implementation of these policies.

A possible support to communication in RM could be found in the intranet. A kind of intranet can be based on portal technology or oriented to get portal structure. Rose (2003) indicates that portals are sets of technologies that provide access to services and resources. The access can be in many ways, but the point is whether the access refers as well to communication among people. Thus, the question is whether the communication can be improved through the intranet. Then the item used was: *the risk management intranet supports communication among risk management people.*

- Maier and Remus (2003) examine the ways that a KMS has been implemented in some organisations, and conclude that an approach based on business process orientation can provide value to the organisation. The business processes can be supported by corporate intranets, customer relationships and supply chain management tools. The question is about the use of these tools in risk management. The interest of RM is associated with the achievement of a good performance in each task and the protection of the results of the organisation (Sections 2.2.2 and 2.2.3). In particular, the desire to find support to risk control is included in the RM activities.

Risk control and ERM could be enriched by the benefits of using integrated intranets. However, in the multiple benefits of using integrated intranets such as, similar interfaces and unique web maps, naming conventions and updating capacity, risk control is not mentioned. As Watson and Fenner (2000) state: “Unfortunately, in many companies, multiple intranets and groupware applications have been deployed in isolation, adding even more silos of information to the corporate coffers.” There are many features in a portal environment (Watson and Fenner, 2000) that are possible to use and the question is whether it is possible to use them for improving risk control and ERM capacity. Therefore, the item used was: *the risk management intranet supports risk management controls.*

In previous sections and when processes and technology have been included in the construction of variables, the concept of integration has appeared. Integration is part of the ERM mandate and from the RM point of view risk control needs to integrate results and sources from different RM areas or from business areas. Likewise, integration can be part of the risk management information system design, and in this research, the perception of integration of RM employees is needed given the system support that is required to perform enterprise-wide RM tasks.

3.8.3. Perceived value of information systems integration

Complex, large organisations and multi-divisional businesses require the design of an enterprise architecture plan in order to support the businesses' access to data and systems. Data should be in formats that are accessible and usable by many different users, and of sufficient quality to share and adopt in business processes.

Zachman's framework (1997) differentiates data, processes and technology factors for the architecture plan, by thinking about the evolution through time that the organisation will have. This means the architecture plan takes into consideration the evolution of the information systems, the user evolution, as well as the changes in the policies, experiences, culture, documentation and strategy support.

Additionally, the stage of evolution of the organisation modifies the use of tools and approaches to problem solving. Gottschalk (2008) indicates the stages of the design of organisational systems, such as people to technology, people to people, people to documents, and people to systems. Each one of these options could need standardization of "personal productivity tools". Maier and Hadrich (2008) indicate additionally, the need of a platform with: a much different functionality with IT, human centric design and that integrates services as well as including the architecture that connects knowledge shared and services.

The steps in the process of defining a business strategy (David 1999) are presented independently, but it is not clear how the areas involved have to be coordinated in order to achieve goals and gain value from common efforts. A key element in this strategy model is the concept of the business model and how to organise the company around it based on information systems support. Organisation processes consume information from various sources and with different applications, the orientation to integration policies might be positive to the organisation.

For example, Earl (2000) explains the evolution of organisations looking to adapt their capacities to business in an information age. The transformation process of the organisation is the last stage, after passing from external communications to e-commerce, e-business and e-enterprise. The concept of the transformation stage has a critical factor that is continuous learning. This factor is affected by change under a dynamic model of mindset that requires higher coordination and consolidation.

Organisations are changing, and there is a request for new processes and technology support to adapt to new business challenges. Financial institutions appear to be preparing themselves for that stage currently. This research regards KM as a piece of this transformation and aims to understand how KM can help to manage risk and to help financial institutions reach the transformation stage. Particularly, information systems have to be more efficient, effective, and integrated in order to help people to make more complex decisions in a transformation process. Then the hypotheses formulated were:

H7a: The perceived integration of the information systems is positively associated with the perceived quality of risk control.
H7b: The perceived integration of the information systems is positively associated with the perceived value of the ERM implementation.

The variable perceived value of information systems integration (variable label *isi*) was constructed based on the following 6 items:

- Laware (2008) indicates that: "Without naming, defining, categorizing, standardizing, and storing both data and metadata, the utility of Web mining, warehousing and KM is suspect." This refers to a key aspect of standards in information management. However, the standards are a piece to improve KM. Rollet (2003) concludes that there is another level of standards, that is the one that allows exchange of information. ”Trying to standardize the functionality of systems may not make much sense but appropriate standards for exchanging information will allow different tools to work together.”

Besides, the different regulatory frameworks in financial institutions are advocating an integral RM view (Crouhy et al., 2001). The practice of RM includes principles that are common for different risks, such as the search for quantification, the need of getting the best option to protect the organisation based on insurance or derivatives, etc. One of the points that Levine (2004) notes is the flexibility capacity of the system this because of compliance that is part of the management objective. The system needs to provide RM basis for applying the normativity to different risks. Levine (2004) identifies that access, control standards and real time are components that should be common to different departments in the RM organisation.

This view was complemented by Mitchell (2006) who indicates that format for applications, interfaces, synchronization, and transference are fundamental points to align. These two above points indicate that the risk management system should probably start with the definition of what is an applicable standard for RM groups and systems tools. Therefore, the item used was: *the same standards are used*.

- Maier and Remus (2003) indicate that the process-oriented KM strategies have different approaches, content, and technology to provide access to knowledge and storing all the knowledge related to various participants of the strategy. Data is the basis of the process control and operation. The point is how data is organised in a business process in order to develop the value-creating activities. The standards can be in place and the application that can be common to RM areas but the point is if regarding data the standards are well defined. This means that it is part of the process of a risk management system design to identify the way in which to keep a repository of data that supports different areas, users and risk analyses. Data architecture is the basis of the proper data use. Similar to the previous item, Karr (2005) expresses the need for a common data structure to support alignment of objectives and the management of strategic linkages for risk performance measurement. This is complemented by Mitchell (2006) who introduces the issue of dealing with the data legacy of different applications. The item used was: *a common data structure is used.*

- Sharma et al.(2008) indicate that the data warehouse is the main component of KM infrastructure. Then, a system structure could be required that includes the development of a data structure common to RM groups. The data system structure is represented by a central data repository of common access. Crouhy (2001) expresses the need to have integrated risk models, standards, risk limits, information technology, and architecture best practices in order to manage risk across the organisation. In addition, Samoff and Stromquist (2001) identify the concept of knowledge databases that can be the basis for integrative actions in the organisation; databases that in an ERM environment are part of the support for the ERM implementation. Thus, the need for a data system structure is part of the system design and the improvement of risk knowledge needs work in the integration of RM areas. Then, the item used was: *a common data-warehouse is used.*

- Jennex (2008) expresses the view that there are some recommendations that a system has to meet in order to support a KM process and some of them include: common architecture and interfaces, data base access to users, and documents under some standards. One of these is report integration as it is needed when data is reviewed, but risk control and ERM need to connect users to the system and offer options that provide access to different areas. One of the ways to provide access and interaction with the systems in risk management is through the development of connection means that are accessible to organisational layers. One is the presence of a common interface when different people are in front of the system, in particular in the ERM program (Abrams et al. 2007). There is not a clear indication that people from different RM areas can get access to the risk management system using a common interface. Then the item used was: *a common user interface is used*.

- The bases of integration introduce the point of what happens with the possibility of generating reports using common and consistent report system modules. Karr (2005) and Damianides (2005) present analyses regarding reporting and performance measurement and indicate how report structures and control of data reported provide consistency to the organisation. However, the reports can be created by different areas and in RM sometimes using different data, different definitions of exposure or loss etc, These differences of reports definitions introduce complexity to the interpretation of the results. The need of integrated actions is described as part of the compliance of regulation, but the unification of report production is not presented as a specific point to take into consideration. Then, the item used was: *a common report system is used in the ERM program.*

- Kim et al. (2003) indicate that: "Knowledge management architecture, the most important outcome of the proposed methodology, consists of knowledge, process, organisation, and information technology architecture." These components of the KM architecture include applications. The access in RM is fundamental because many of the actions require simultaneous access, for example, market information, transactions and analysis, which can be supported by independent tools. Moreover, Dinner and Kolber (2005) use Zachman's model to identify the integration of applications and data in systems integration actions through portals.

  However, in RM applications the integration is not clear because applications can be associated with pricing, production, exposure and many other areas. The applications can be defined in different settings and to have different means to access them. RM can have different applications and to reach them through one means for all users can support the RM processes and possibly KM processes. Additionally, Boh and Yellin (2006) identify issues before the integration and the capacity of the organisation in order to leverage technology across the organisation. Then, the item used was: *a common application access is used in the ERM program.*

The integration concept in the RM setting is part of the possible risk management system design. This is complemented by the analysis of the general concept of network for connecting people in the RM group. Thus, the next section examines the variable Network capacity for connecting people.

3.8.4. Quality of network capacity for connecting people

In financial institutions, as elsewhere, the view of Von Krogh and Roos (1995) applies; namely that the bases of knowledge creation are the individual minds and their relationships. The process of knowledge creation relevant to ERM by individual minds within an organisation requires three elements. First, identification of the ways to transfer tacit to explicit knowledge and vice versa (Nonaka and Takeuchi, 1995); second, understanding of the flows of information and how they produce knowledge (Choo, 1998; Weick, 2001); and third, the way that the risk knowledge is organised (Wiig, 1993). All of these requirements are related to the organisation's capacity to connect people for knowledge mobilization.

Typically, there is emphasis put on the cost of integrating risk analyses, control, and risk policy creation, deployment and application (Cumming and Hirtle, 2001). This could be a step towards the construction of a risk knowledge portal in order to connect many sources of experience (content integration), explicit and tacit knowledge, the measurement process, and the capacity to manage operations at an acceptable cost (Firestone, 2000; Kesner, 2001; McNamee, 2004; Detlor, 2004, Spies et al., 2005; Warren, 2005).

Such portal support can be a good vehicle for risk knowledge sharing, given the difficulties of the language spoken inside the organisation related to risk and that of applying expertise to solving different problems (Dickinson, 2001; Warren, 2005; Shaw, 2005). Considering that web search tools are crucial in RM (Simoneau, 2006), some support must be provided to make users more effective in the search process, because people do not search effectively when there is a high volume of knowledge available, such as in RM (Alavi and Leidner, 2001).

Equally, there are other requests for better risk knowledge sharing, such as consolidation and integration of internal information, reporting, data for reducing operational risk in financial institutions (Marshall et al., 1996; Shaw, 2005), and better cross-selling and web services (Anderson et al., 2005) as support to people's work. Thus, a KMS and information management can be needed for actionable answers to risk threats (Sutcliffe and Weber, 2003). The KMS requires to take into consideration that the technical and organisational strategies for KM affect knowledge transfer (Alavi and Leidner, 2001).

The KMS implementation needs the identification of stakeholders and the association of their different types of knowledge (Lehaney et al., 2004). Additionally, Earl (2001) introduces as a success factor for KM implementation, the networking capacity for connecting people in the organisation. In risk control and ERM implementation could be an advantage to interrelate technological, methodological and business factors; however, is not clear a relationship of networks and RM. Thus, the hypotheses formulated were:

H8a: The quality of the network capacity for connecting people is positively associated with the perceived quality of risk control.
H8b: The quality of the network capacity for connecting people is positively associated with the perceived value of the ERM implementation.

The variable quality of network capacity for connecting people (*nccp*) was constructed based on the following 5 items:

- Vaast (2008) concludes that the intranet features support the communities of practice through inter-operativity, cost and time efficiency, flexibility, privacy, and user friendliness. Portals can be a solution across the organisation to connect people, and Dinner and Kolber (2005) introduce portals as a piece of the system architecture to develop due to the variety of business and activities that organisations have. The point that they bring to the discussion is whether the IT architecture and the financial institutions as multi-business have an enterprise portal structure supporting interdepartmental work. Equally, Tamriverdi (2006) studies the performance in multi-business firms and identifies the importance of remote access and allocation facilities for a better organisation performance. Thus, the item used was: *there is an enterprise portal structure supporting interdepartmental work.*

- The portal structure can support the organisation searching for collaboration in order to achieve what Cai (2008) said: “During collaboration, each individual has a perspective that evolves over time and acts like a “lens” through which she understands and collects information external to her." The portal structure can be available and only some of its features can be implemented in the organisations. Portals can be supporting collaboration tools among users. Swan (1999) points out that independent intranet sites limit knowledge sharing and in a RM environment, a common structure could support the different RM groups particularly for collaboration. The question is whether the portal solution included the collaboration features in the current solution. Thus, the item used was: *There are collaboration tools easily available.*

- Elshaw (2008) indicates the value of teams and that they can be potentialized using means to access expertise. "One of the great strengths of a team is the ability of its members to work together and build on each other's ideas." He further states: "For the organisation, the ability to boost productivity by making best use of their expertise, wherever this resides, is of great benefit." These means are virtual teams that support ideas for increasing skills and expertise in contact with more people. Zack (1999a) introduces what he calls the knowledge management architecture and indicates the need to have repositories of explicit knowledge and technology to support the KM processes. This means particularly "defining, storing, categorizing, indexing and linking digital objects..." which is possible with web based workspaces.

  Even having access to collaboration tools, the RM group can need workspaces where documents, data and news can be shared. RM groups of work might be supported by virtual workspaces. Small and Sage (2006) describe the knowledge sharing process, and some factors that they mention contributing to knowledge sharing are related to web technologies. There is not a clear identification of using workspaces and web technologies to develop virtual work in RM. Then, the item used was: *people use web based workspaces for working on projects*.

- In addition to the architecture design, Zack (1999a) expresses the fact that "knowledge management applications form a continuum from low to high interaction complexity." There is a possible solution for several teams to work together but that requires "multiple repositories segmented by degree of interactivity, volatility of content, or the structure of the knowledge itself." The work spaces might facilitate interdepartmental work. The accumulation and administration of virtual workspaces might contribute to the performance conjoint activities. The point is that possibly the risk knowledge sharing can be stimulated by the use of solutions as Alavi and Leidner (2001) point out; the easier technologies, the easier the knowledge transfer. The item used was: *solutions were created because of multi-departmental work*.

- As a complement to the above points, in the network capacity to connect people Boersma and Kingma (2008) refer to intranets: "As argued above, an intranet can facilitate knowledge sharing among organisation members. The idea is that the knowledge put on the intranet is explicit knowledge that can easily be shared by members of the user group." People can have the tools to work together, but the question is whether the RM employees consider that the features in a network provide a value and facilitation for their work. People need to perceive that interaction is easy to share knowledge. There are tools, actions and policies that can promote sharing knowledge and one is the motivation to share and access (Small and Sage 2006). Then the item used was: *sharing my work with others is easy.*

3.9. Summary

This chapter has expanded the general literature review of Chapter 2 in order to focus on the definition of variables and items. Variables have been reviewed from the literature in the context of RM and KM in general; even though, the variables by themselves do not appear in previous studies. The items used for the variables have been linked and identified to the literature in order to clarify their meaning and how the literature in general has referred to the concept that is used.

The literature review explained the selection of the dependent and independent variables with the items describing each construct. A total of 53 items were described and a total of eight hypotheses per dependent variable were formulated.

Based on the points above, the next chapter will present the bases of the research, sample, identification of the variables, and transformation of the original data in order to perform the analysis.

4. Chapter Four Research methodology

This chapter includes the review of: research basis, population of interest, data transformation, definition of independent and dependent variables, and the model structures used. The introduction to this document identifies the aim of this research as: to contribute to the RM and KM literature by identifying the relationships between the variables describing the KM processes, in particular knowledge sharing and the RM management variables: perceived quality of risk control and the perceived value of the ERM implementation. The search for the relationships follows four objectives: First, to identify the knowledge and risk management constructs and their related items to use as a basis for research in the field. Second, to identify and put together existing work in each discipline where there are commonalities in application to financial institutions. Third, to seek the KM variables that can influence the perceived quality of risk control and the perceived value of ERM implementation. Fourth, to identify the bases for supporting KM in RM through a KMS design In order to achieve these objectives the research methodology used is described as follows:

4.1. Research basis

This research has as the main purpose the identification of the relationships between eight KM variables and two RM variables, referring to the concepts of risk control and ERM implementation. The identification of these relationships is organised, as indicated in Chapter Three, through the selection of the items and variables and based on the performed literature review. The purpose of using these different items and variables is to study the relationships describing people, processes and technological aspects.

The research has a positivist approach that provides the possibility of building a relationship model, formulating hypotheses and testing them statistically (Babbie, 1998). The positivism approach (Delanty, 2002) considers as fundamental the methods used in natural sciences and the purpose of science as the study of the reality which exists outside of the observer values and the possibility of studying it objectively. The positivist approach is based on observation and on the formulation of hypotheses to be validated.

These hypotheses were formulated in terms of the level of association among variables and the results can be used to test new hypotheses or to generalize results; equally, the analysis can include qualitative and quantitative components for clarification of concepts and relationships (Babbie, 1998; Miller, 2002). One of the aspects that is important in the positivism approach is that it allows for the creation of rigorous models to support the inference of the variables and their use in the improvement of risk control and ERM implementation (Guba and Lincoln, 1994).

To accomplish the research objectives this research uses quantitative methods and includes survey and statistical modelling to test the relationships. The survey is a useful method for answering questions about what, how much and how many, and allowing comparison among variables (Pinsonneault and Kraemer, 1993). Some additional points indicate that the survey was an appropriate tool for this research (Wimmer and Dominick, 1994):

- The statistics regarding the responses provide the frequency of answers that allow for a quantitative analysis and statistical test of the hypotheses.
- The closed-ended questions allow the comparison of the variables and the possibility of statistical analysis, independently and in combination.
- The structure of the survey and the content of the questions are crucial for getting coverage of the subjects required in the research.
- The number of questions and variables used is limited.
- The codification for quantification is feasible through the survey which is complex in non-structured data gathering tools.
- The respondent is not identified, and different criteria from different people of the organisation reduce the bias in agreement questions and answers.

The survey is a method that provides a quantitative description of the relevant variables; the results might be extended to the population, the data obtained from the items provides the possibility of testing if the constructs used were reliable, in particular in this study where no previous studies have been performed; additionally, the survey provides gathering data that with statistical method provides objective evaluation of the relationships with the comparison of variables relationships in a bivariate way or in multivariate way that is represents better the reality of variable interaction. Finally, the survey opens the opportunity to use these results in projecting them to the KM processes implementation and to provide bases for further studies in the field of KM applied to RM.

In this research, the survey was applied to a random sample of full-time employees in the Risk Management area in financial institutions. The survey uses the method of a questionnaire. The questionnaire is used for the hypothesis testing where the majority opinion about the issues and opportunities identified is important. There are different methodologies in applying a questionnaire. The application uses face to face questionnaires, mailed questionnaires, telephone questionnaires and web-based questionnaires. The pre-test of the questionnaire among people in the risk management field allows for identification of ambiguities and incorrect formulation of the questions. The pre-test consisted of preparing the items and questions and then testing them with people working in the risk management area. They suggested modification in wording related to the terms used for referring to web channel functionality, perceived value of ERM implementation, and the identification of item terms such as risk management intranet and interdepartmental and interdisciplinary work.

Given the population literacy in systems and the capacity to work individually, this research uses the following methods to perform a survey:

- Face-to-face questionnaire: This method was used in the questionnaire testing step where the majority opinion was gathered with the respondent in front of the researcher, allowing specific closed questions regarding the subject.

- Electronically web-based questionnaire: once the questionnaire was tested and the data gathered was reviewed an electronic web-based questionnaire was performed (Aaker and Day, 1990). These authors pointed out: “since each of the basic methods of data collection has different strengths and weaknesses, it is sometimes desirable to combine them and retain the best features of each while minimizing the limitations.”

  This method has the following advantages (McDaniel and Gates, 2006): Rapid deployment, real time reporting, reduced costs, high response rate, and data is input directly to a database in order to use it in the analysis step. The follow-up was the key for improving the answer rate in this method based on the main benefit, for the respondent, that the questionnaire is available any time on the web (Saunders et al., 2003).This is the desired design; however, this is the method with more weaknesses with regard to internet security, potential unrestricted access and the possible poor representation of the population because of internet access and computer literacy. The weaknesses were reduced given the application to the risk management association members.

The sampling was based on the assumption of randomness, unknown population size and a specific period of time for gathering the data (Johnson and Onwuegbuzie, 2004). The selection of the sample is based on two steps: First, RM employees of bank headquarters (risk management is an activity with centralized operation) were contacted and those who accepted the interview were visited to gather the data.

The second step was through an email invitation to participate in the survey to risk management association members who worked for financial institutions. This invitation was directly using the email address that was provided by the member to the association. The association portal provides capabilities to filter the organisation subsectors and regions in order to target financial institutions offering services of banking and insurance (see Financial Institution definition in Section 1.1) and mainly in North America. The selection is not probabilistic but the participation is at random.

The sample selection method was appropriate because those involved in activities in the field of RM in financial institutions represent a homogeneous population, given the type of organisation, the activities that they perform, problems that they are required to solve and roles that are the basis of the RM group in financial institutions. The application of the questionnaire using face-to-face and online methods was an appropriate choice of methods for the respondents to have access to the data-gathering instrument. Additionally, these methods allow for gathering enough data in order to find relationships between the variables using statistical tools. This is crucial because many of the relationships among variables are not possible to perceive just in a descriptive review, but require the use of multivariate techniques (Wimmer and Dominick, 1994).

The identification of the variables and items describing these variables (see Chapter 3) was based on the concepts exposed in Chapter 2, in order to provide the control of the research. This means the variable control and the inclusion of the predefined items of the variables helped to maintain the focus of the research (Frankfort-Nachmias and Nachmias, 1992) and to reduce subjectivity (Balsley, 1970).

In summary, the development of the research, assuming a positivism approach, comprises a quantitative analysis of the variables and a statistical validation of the hypotheses in order to identify the bases for the KM and RM relationships.

4.2. Population of interest and sample

The unit of analysis is the RM employee who is involved in RM activities in any of the RM processes in a financial institution. This project only intends to investigate RM employees as a whole and not any sub-division within the finance industry. The groups of RM employees are exposed to the KM processes in a similar way given the centralization and corporate level decision processes that any designs of the information systems, policies and strategy definition require. This provides values of the proportions for perceptions relative to the attributes analysed, across RM people working in a financial institution.

The survey comprising the items explained in Chapter 3 (See Appendix 9.1 for the survey) was distributed to 620 full-time employees in the RM area in financial institutions (most of them members of the Professional Risk Managers International Association and Risk Management Association RMA); 102 responses were received via the web and 19 face-to-face. The population was based world-wide, although more than 50% were from North America.

Although a web-based survey can have its limitations as a general survey method, as was indicated before the weaknesses were reduced because all RM employees in the financial sector need to be computer-literate and all have web access at work. It was therefore thought unlikely that responses would be biased as a result. The survey was pilot tested by RM professionals and academics: only minor modifications were made as a result of the pilot. The initial questions in the survey covered demographic information such as number of years in RM work, followed by the actual item questions. In total, 121 usable responses were received, giving a response rate of 19.5%.

4.3. Measurement and data transformation

All 53 items in the survey were rated on the same Likert scale: 1 strongly disagree, 2 disagree, 3 neutral, 4 agree and 5 strongly agree. The Likert scale is used in this research in order to include the options to the respondents for evaluating the agreement, preference and attitude, on the statements (Aaker et al., 1998) that each category has for each variable. Values for the variables were then derived from the item scores associated with each variable.

An important issue in aggregating item scores was not to assume that simple addition of the item scores (i.e. equal weight) would be accurate (Alfares and Duffuaa, 2008). Three different methodologies were reviewed for assigning weights to the original results. The first method was the evaluation of the total sum of item values over the total sum of all item values. This method did not take into consideration the mean and the variance of the item values. The second method was based on the construction of a matrix that has by rows the accumulated relative frequency per Likert scale. The original value was changed by the value given by the accumulated relative frequency. This method did not include the variance of the distribution.

The third method, that was the selected one, uses the transformation of the original data to a new one given by z-score $(x-\mu)/\sigma$, (Bohrnstedt and Knoke, 1982) where μ is the mean and σ the standard deviation. This method allows for identifying how far the observations are from the mean measuring how many standard deviations a value is above or below the mean. This transformation allows for the comparison of the factors with a different mean and standard deviation because they were converted to the same scale. Additionally, the standardization allows for measuring everything with the same units, which are standard deviation units. This means all the results are comparable. The z-scores do not change the skewness and kurtosis of the distribution, or the correlations between items (Bohrnstedt and Knoke, 1982).

4.4. Independent and dependent variables

The following variables were used in the hypothesis formulation:

Independent: The independent variables were demographic and those describing the KM processes in RM. The demographic variables are: risk management area of work, risk management process on which most time is spent, length of time in the current position at the time of the survey application and length of experience in risk management. The KM variables are independent quantitative interval variables(Bailey, 1978), the ones resulted of the transformation using the z-score and that were built from the items with a Likert scale as previously indicated. The non-demographic variables are all KM concepts including the concepts of people, process and technology: (See Table 4-1 for Variables and Items)

People

- Organisational capacity for work coordination(*cwc*)
- Perceived quality of communication among people(*pqc*)
- People's interaction for risk information system design(*iis*)

Process

- Perceived quality of risk knowledge sharing (*qrks*)

Technology

- Web channel functionality(wcf)
- Risk management information system functionality(*misf*)
- Perceived value of information systems integration(*isi*)
- Quality of network capacity for connecting people(nccp)

Variable	Items
Organisational capacity for work coordination (cwc)	• The organisation encourages interdisciplinary work • The organisation encourages interdepartmental work • There are good web based collaboration tools • People are willing to work with multiple groups • There are guiding principles for working with different groups • There are standards for using collaboration tools
Perceived quality of communication among people(pqc)	• The communication between the Risk Management groups is good • The communication within my Risk Management group is good • The communication environment fosters the interchange of different points of view • There is a good capacity to get conclusions easily during meetings • The communication environment promotes team work
Perceived quality of risk control (qrc)	• The risk mitigation tools are good • The risk assessment process is good • The risk transfer process is good • The risk product evaluation is good • The risk aggregation analysis is good
Web channel functionality (wcf)	• The Risk Management Intranet provides access to collaboration tools • The Risk Management Intranet provides access to all applications used in risk management • The Risk Management Intranet provides access to the proper data • The Risk Management Intranet facilitates interaction in problem solving process • The Risk Management Intranet supports communication among risk management people • The Risk Management Intranet supports risk management controls
Risk Management Information systems functionality (misf)	• The systems provide support to the risk modelling process • The systems provide access to experience in risk analysis • The systems provide adequate data management support • The systems provide capacity to improve work flow • The systems provide capacity to work with multiple groups on a project
People's interaction for risk information system design(iis)	• Perceived quality of people interactions in the ERMIS design
Perceived quality of risk knowledge sharing (qrks)	• People are willing to share risk knowledge • The availability of documentation is good • The access to experience is good • There is an appropriate environment to discuss results interdepartmentally • There is an appropriate environment for the creation of shared solutions
Perceived value of information systems integration (isi)	• The same standards are used • A common data structure is used • A common data-warehouse is used • A common user interface is used • A common report system is used • A common application access is used
Quality of network capacity for connecting people (nccp)	• There is an enterprise portal structure supporting interdepartmental work • There are collaboration tools easily available • People use web based workspaces for working on projects • Solutions are created because of multidepartment work • Sharing my work with others is easy
Perceived value of ERM implementation(perm)	• ERM improves collaboration • ERM promotes our experience sharing • ERM reduces the number of times we reinvent the wheel • ERM improves the quality of data • ERM improves our interdisciplinary work • ERM improves our interdepartmental work • ERM improves our understanding of model results • ERM improves our problem solving process • ERM improves our capacity of mathematical modelling

Table 4-1 Research variables and items used for their construction

Dependent: this research uses two dependent variables, one in each model and each part of the problem formulation: first, the perceived quality of risk control (*qrc*); second, the value of the ERM represented by the overall perception of the value of ERM implementation (*perm*). The first variable allows for the analysis of the relationships of KM and the specific actions of risk control, or better follow-up to the implementation of RM policies. The second dependent variable identifies the level of the perceived value of the implementation of ERM through the lens of the RM program across the organisation and based on items associated with the RM task execution and support to the operation.

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4.5. Validity and Reliability

Churchill (1979) stated that a measure is valid when:"[t]he differences in observed scores reflect true differences on the characteristic one is attempting to measure and nothing else." He continues by saying that a measure is reliable "[t]o the extent that independent but comparable measures of the same trait or construct of a given object agree." The following two sections review the validity and reliability of the measures.

Validity:

This is "the extent to which a construct measures what it is supposed to measure." (Hair et al. 2003) To assess the validity in general there are three methods: First, content or face validity: this is a systematic and subjective assessment of the items used for building the construct. In general it is based on expert judges and pretests (Hair et al 2006). This research used pre-test and the review of the text, by people with no formal training in the research subject, of items looking for a formulation in plain English or wording with clearer meaning for the respondents.

An example is the term web channel that was used in the variable and items but based on the review it was kept for the variables but changed to intranet for the items. Equally, in the first versions of the text the word "system" was used; this was later changed to "systems" given the variety of systems that the risk management area uses. The review by people from the Royal Bank of Canada with risk management but not KM expertise helped to identify how to present the items to RM people. This was complemented with the face to face survey application by the researcher and observation of understanding of the terms used, in particular the adjustment was to avoid technical KM terms in the item formulation while at the same time relying on the literacy of RM people in computer and web related topics.

The other validity review is using construct validity; " assesses what the construct (concept) or scale is, in fact, measuring." (Hair et al. 2003). In particular convergent validity was used. It uses the correlation between two constructs that are potentially measuring the same concept. Trochim and Donnelly (2007) pointed out that it is possible to use the significant correlations among items to demonstrate that the items are "probably related to the same construct" and referring to a specific example "we can assume from the pattern of correlations that the four items are converging on the same thing, whatever we might call it." The correlations result positive significant for all items except cwc1-cwc5 and qrks1 and qrks5, 2 out of 53 items providing evidence of convergent validity (See Table 9.8)

Third, criterion validity: "assesses whether a construct performs as expected relative to other variables identified as meaningful criteria." (Hair et al., 2003) There are two checks. Concurrent validity reviews the association between the construct that is being validated and the concept from the theory using different groups. In this research there is no previous KM study of risk management people to use. Predictive validity is what it is possible to predict from a measure of the construct at a specific period of time. This was a cross-sectional study, and so no test of this kind was possible, even if a suitable prediction could have been determined.

Reliability:

A survey is reliable if in a different application the scores are consistent (Hair et al., 2003). Three methods are used for testing reliability: test – retest, alternative forms reliability and internal consistency reliability (Churchill 1979). In test – retest reliability evaluation is through the application of the survey to the same respondents in a repeated way, "Finally, it often is very difficult and sometimes impossible to have the same respondents take a survey twice." (Churchill, 1979) Equally the time and mood could modify the results. The correlation between the answers measures the test-retest reliability and can be high because of the memory of respondents. In this research the application of test-retest was not possible because of time and contact factors that are related to people in RM and no validated scale was available. Churchill (1979) continues emphasizing that he does not recommend using test-retest because of the respondents' memories.

Alternative forms reliability consists of the presentation of two different forms of the construct. The correlation of the two answers to the two presentations of the construct identifies the alternative form reliability. This option is not available in this study, particularly because the constructs are new, there is no literature using the same variables or items to take as direct reference.

The third method is the internal reliability, which is recommended when various items are used to form a score that describes the construct. This research used mainly the internal reliability measure because the variables are built through the items selected from the literature review without previous scales used. The internal reliability uses the coefficient Cronbach's alpha to determine it. Churchill (1979) pointed out that alpha coefficients measure internal reliability but not the effect of external factors such as conditions of the respondents through time. He continues saying "The recommended measure of internal consistency of a set of items is provided by coefficient alpha which results directly from the assumptions of the domain sampling model." And adds "Coefficient alpha absolutely should be the first measure one calculates to assess the quality of the instrument."

As was said at the beginning of section 4.4 the variables were built using five or more items. Only one variable had one item: quality of people interaction for risk information system design. The reason was the clear meaning of people interaction when a project or activity is performed with various people. The items used to construct each of the other variables were tested according to their Cronbach's alpha coefficients. The cut off value considered to be acceptable is 0.7 (Cortina, 1993; Hair et al. 2003). The Cronbach's alpha coefficients (See Table 5-1) were required to show if the items for each variable were consistent and the scale reliable. Based on the results of the Cronbach's alpha coefficient, it allowed for that the transformed z-scores for the items may therefore be added together to give the value to be assigned to the variable.

4.6. Statistical analysis, models and their assumptions

The data analysis started by examining the data and it was observed that there were some missing data. Missing values for item scores were dealt with by replacing the missing value with the mean score for that item, as recommended by Han and Kamber (2006). A total of 45 of the responses contained one or more missing values.

The methods used to analyse data were the following:

Exploratory data analysis

An exploratory data analysis was performed between the variables and the items that formed each variable. Exploratory data analysis (Berry and Linoff, 1997; Parr 2001; Dunham, 2003) is a set of statistical techniques for analysing data. It includes graphic and quantitative techniques. In this research the techniques used were: Cronbach's alpha coefficients analysis, summary statistics analysis, distribution analysis, demographic distribution analysis and correlation analysis.

- Cronbach's alpha: The alpha coefficients are an internal consistency reliability indicator (See Section 4.5). The coefficient alpha is: "the average of the coefficients from all possible combinations of split halves." (Hair et al., 2003) The split-half refers to the division of the items in half and correlates the two sets of items. The search for each variable and the items was performed and the values compared to the threshold of 0.7 minimum level of acceptance.

- Summary statistics analysis: This group of measures is represented by the search of statistical attributes of the sample by each variable: Anova test for means difference, mean, variance, kurtosis, and skewness.

  Analysis of variance (Anova):

  The general model for one factor is:

  $$Y_{ij} = \mu + \tau_i + \varepsilon_{ij}$$

  Where Y_{ij} represents the *j-th* observation in the i group, μ represents the mean of the whole sample, τ_i is the factor per group i and ε_{ij} the error of the *j-th* observation in the i-*th* group

Anova tests the overall model to determine if there was a difference in means between the members of groups, time of experience, time in the position, risk management process and risk type. The Anova has some assumptions: subjects are randomly assigned to one of 3 or more groups and that the data within each group are normally distributed with equal variances across groups. Sample sizes between groups do not have to be equal, but large differences in sample sizes for the groups may affect the outcome of some multiple comparisons tests.

The test statistic reported is an F-test with k-1 and N-k degrees of freedom, where N is the number of subjects and k the number of groups (N can be different in each group (Spiegel, 1997)). A low p-value for the F-test is evidence to reject the null hypothesis. In other words, there is evidence that at least one pair of means is not equal.

The hypotheses for the comparison of independent groups are: (*k* is the number of groups)

H_o: $\mu_1 = \mu_2 \; ... \; = \mu_k$ (means of all groups are equal)

H_a: $\mu_i <> \mu_j$ (means of two or more groups are not equal)

The test used for the means is Tukey's test and for the variance Levene's test. Tukey's test compares the means among groups and compares the differences in means to the standard error. This is a test used when the sample sizes of the group are different and values greater than the alpha value (5%) indicates no significant difference in the means. Levene's test is used to test for equal variances between groups. The advantage of this test is that is used for groups of different sizes. Values greater than the alpha value (5%) indicate no significant difference in the variances.

- Distribution analysis: This analysis consists of observing the histograms. Q-Q and probability plots, as well as the formal tests of normality, in order to identify whether the variables are described by the normal distribution or not. The demographic distribution analysis refers to the distribution analysis using the groups. The tests used for normality assessment was the Kolmogorov-Smirnov at the 5% level. The use of the Kolmogorov-Smirnov test is suggested as follows: ”An alternative strategy for evaluating the normality assumption is to evaluate the values computed for standardized residuals with respect to goodness-of-fit for a normal distribution. The latter can be accomplished through use of one of the goodness-of-fit test described in the book, such as the Kolmogorov-Smirnov goodness-of-fit test for a single sample …” and “ the Kolmogorov-Smirnov is designed to be employed with continuous variables .”(Sheskin, 2007), Similarly, “ The Kolmogorov-Smirnov (K-S) test is used to decide if a sample comes from a population with a specific density. It is used because the distribution of the K-S test statistic does not depend on the underlying cumulative distribution function being tested and because it is an exact test.” (Cohen and Cohen ,2008).

- Correlation Analysis: The correlation analysis used for a general view under the assumption of normality of variables was Pearson’s Coefficient and for the non-normal and ordinal variables Spearman’s coefficient.

Multivariate Analysis:

A multivariate exploratory data analysis was performed. The method selection took into consideration the following options:

- The use of SEM (Structural Equation Model)
- Multiple regression, with and without interactions
- Stepwise regression
- Review of the regression results using power analysis

The use of SEM

The use of Structural Equation Models (SEM) was considered. Hair et al.(2006) explain, “SEM estimates a series of separate, but interdependent, multiple regression terms…Thus, some dependent variables become independent variables in subsequent relationships…The proposed relationships are then translated into a series of structural equations (similar to regression equations) for each independent variable.”

The number of combinations of models can be enormous if there is not a pre-identified set of causal (path) models, Hair et al. (2006) said that the fit is for the selected model and it depends on the selected structural equations. The scope of this research is exploratory: the identification of relationships among KM and RM variables but without a previous path model. The lack of a previous path model would have meant considering many variable combinations for relationship identification.

Even if identified, a SEM model could have a good fit but it does not mean that the selected model is the only one, it is just one of the acceptable ones (Hair et al. 2006)..Kale et al. (2000) pointed out that without previous work identifying some kind of relationships, path analysis, and causality might produce a search of relationships without boundaries. Thus the use of SEM was not feasible at this exploratory stage in the research.

The use of Multiple Regression

The multiple regression provides means for the validation of the hypotheses. Each model is built for evaluation of the relationships to the two dependent variables. The regression models allow the analysis of the variables using first the whole sample and the demographic groups as well. During the data analysis some other models were tried. In particular multiple regression with interactions,(see Appendix 9.4 for examples of two variable interaction). The results did not deliver any new insights in terms of model quality to the research and the interpretation of the coefficients became complex because some of the significant interactions were negative.

Thus, the regression models formulated have the following structure:

$y_i = \beta_0 + \beta_1 x_{i1} + \cdots + \beta_p x_{ip} + u_i$ where *i =1...121* and *p=1...8*

That means

$E(Y|X_1, \ldots, X_p) = \beta_0 + \beta_1 X_1 + \cdots + \beta_p X_p$ and $V(Y|X_1 + \cdots + X_n) = \sigma_u^2$ where *u* is the error term, X_i are the KM independent variables and Y is the dependent variable, *qrc* and *perm* in each model.

Hair et al. (1998) indicates the assumptions to be examined for the multiple regression model as follows:

- Linearity of the relationship between independent and dependent variables
- Homoscedasticity: Equality of variance of the errors
- No autocorrelation of the errors and independence of observations
- Normality of the residuals or errors
- No multicollinearity
- No outlier distortion

Linearity: this is the degree of association between the change of the dependent variable and independent variables. According to Hair et al. (1998) linearity is examined using the residual plots. With these plots, the identification of curvilinear patterns can lead to the conclusion of non-linearity.

Homoscedasticity is evaluated using the White test (SAS Reference 9.1.3 and Gujarati, 2003). The White test assumes that under the null hypothesis of no heteroscedasticity the *n* times (n number of the sample points) of the R^2 of the auxiliary regression follows a Chi-square distribution with the degrees of freedom equal to the number of independent variables (regressors of the auxiliary regression) used. The auxiliary regression model uses the error of the original model as dependent variable and is described through the original independent variables plus the squares of the independent variables plus the combination, two by two, of all the variables. This combination of terms in the regression models indicates the number of degrees of freedom for a Chi-squared test.

The autocorrelation of the errors was tested by applying the Durbin-Watson test. Values close to 2 of these statistics indicate data is independent (Christensen, 1997). The rule says that the value of the statistics should be between 1.5 and 2.5 to indicate independence of observations.

For the Normality analysis of the residuals Hair et al. (2003) suggest the review of three plots: the histogram vs. the normal distribution curve, the normal probability plot of regression standardized residuals and the standardized predicted values of the dependent variable against the standardized residuals from the regression equation. The attributes to observe are:

- Histogram vs. normal distribution: Establish if the observation of the histogram of the residuals suggests a good fit to the normal distribution, and if the points of the bars are touched by the normal curve and the difference in the tails does not appear big.
- Probability plot of residuals: Establish if the residuals are close to the diagonal, overlap the diagonal and if only some points appear to be outliers.
- Standardized predicted values vs. standardized residuals observing if there are values out of ranges as Hair et al. (2003) pointed out: “The plot of standardized residuals provides information on the assumption that errors are normally distributed. To assess this, you look at standardized residual plot and determine whether 95% of the standardized residuals are between -2 and +2. If they appear to be, and this is a judgment call, then we conclude that errors are normally distributed.” Johnson and Wichern (1998) indicate possible issues in the patterns to use as reference in the plots analysis.

A multicollinearity analysis was performed: first, using what Hair et al.(2003) pointed out that if there is a correlation between two independent variables that is above 0,7, the variables should be considered to be removed. Second, using two additional indicators for the multiple regression models: Variance Inflation Factor and Condition Index.

The variance inflation factor, an indicator of multicollinearity is a metric that identifies "how much the variance of the regression coefficients is inflated by multicollinearity." (Hair et al.,2003).

The condition index is the square root of the ratio between the maximum eigenvalue and the minimum eigenvalue of the variance-covariance matrix. In the SAS 9.1.3 Reference guide is indicated: "Belsley, Kuh, and Welsch (1980) construct the condition indices as the square roots of the ratio of the largest eigenvalue to each individual eigenvalue... The condition number ...is defined as the largest condition index.... When this number is large, the data are said to be ill conditioned. A condition index of 30 to 100 indicates moderate to strong collinearity... A collinearity problem occurs when a component associated with a high condition index contributes strongly to the variance of two or more variables. Thus, for a high condition index (>30), the corresponding row should be examined to see which variables have high values. Those would indicate near-linear dependence."

No outlier distortion is the search for the observations that have a substantial difference between the predicted and actual value in the dependent variable or a big difference in observations relative to the others, in the independent variables.

The use of stepwise regression

This is the method of variable selection based on the variable contribution to the explanatory power of the model. The variable selection starts with the best predictor of the dependent variable. Variables are added if they increase the prediction of dependent variable or dropped if they reduce that prediction power. Hair et al. (1998) pointed out that the independent variables are selected when their partial correlation coefficients are significant, and: "Independent variables are dropped if their predictive power drops to a non-significant level when another independent variable is added to the model."

The use of Power Analysis

This research included demographic variables as well as the variables related to KM and RM. In order to assess the quality of the regression models this research took into consideration the number of sample points used, the number of variables and the size of r-square. The way to validate if the number of sample points. number of variables and the r-square size, in the regression model, were appropriate was Power Analysis.

In particular the analysis by demographic groups needed the use of Power Analysis (Cohen et al., 2003). The statistical precision and power analysis refer to the standard error, confidence interval and probability of rejecting the null hypothesis when it is false and this depends on three elements: the sample size, the significant criterion and the size of the effect in the population. Power is the probability of rejecting H_o when a particular alternative value of the parameter is assumed or, to put it in another way, power is one minus the probability of a type II error. (Moore and McCabe 1999; Neter et al. 1990; Kleinbaum et al. 2008).

The tables used are in Cohen et al. (2003) and the threshold considered as sufficient power is 0.80 (Murphy and Myors, 1998; Kraemer and Thieman 1987)
The Power Analysis is based on the following concepts associated with R-squared of the regression models:

$f^2 = \frac{R^2}{1-R^2}$ and $L = f^2 * (n-k-1)$ then $n = \frac{L}{f^2} + k + 1$

Where

f^2= Population effect size for R-squared

n= Number of observations

L=Value that is obtained from the L tables for a given power value and number of independent variables

k= Number of independent variables

Non – response bias test

The non-response bias is "[t]he difference between the answers of nonrepondents and respondents." (Lambert and Harrington 1990). These authors indicate that the comparison of the "characteristics that are relevant to the study." leads to the identification of the bias.

Pervan (1998) pointed out, "The danger, however, is in non-response bias, i.e. that those not responding have substantially different views from those who have responded. A recommended strategy for overcoming this is by resampling the non-respondents (Hartman et al., 1985). Such a follow-up survey was conducted and a further 19 responses received…. Tests of the difference in the mean critical score ratings between the 33 respondents in the first round and the 19 respondents in the second round were carried out and no significant differences were found, even at the 0.1% level of significance."

In this research the comparison of the answers between the first group of respondents and the second group who answered after a second invitation to participate in the survey was sent. This second group was taken as sample of those that are non-respondents, The comparison was performed and the results indicate (See Table 4-2) that two of 53 items had a significant mean difference, "[t]he absence of nonresponse bias is inferred"(Lambert and Harrington, 1990).

As these represent one item out of 6 in the variable quality of network capacity for connecting people (nccp) and one out of 9 for the variable perceived value of ERM implementation (perm), it was thought reasonable to assume there was no overall non-response bias. .

Item	Mean early	Mean late	Variance early	Variance late	Test for difference of variances	Test for difference of means (1)	Test for difference of means (2)	Item	Mean early	Mean late	Variance early	Variance late	Test for difference of variances	Test for difference of means (1)	Test for difference of means (2)
Alpha = 0.05 ; N early = 39 and N late = 36								Alpha = 0.05 ; N early = 39 and N late = 36							
isi1	3.05128	3.00000	0.89204	1.02857	0.33298	0.82125		nccp1	2.79487	2.55556	1.06208	0.88254	0.29135	0.29805	
isi2	2.94872	2.77778	1.04993	1.03492	0.48460	0.47121		nccp2	2.61538	2.41667	1.03239	0.70714	0.13061	0.36144	
isi3	3.05128	2.72222	1.41835	0.94921	0.11661	0.19658		nccp3	2.79487	2.13889	1.27260	0.75159	0.05942	0.00642	
isi4	2.71795	2.66667	1.04993	0.91429	0.34106	0.82371		nccp4	3.07692	2.88889	0.96761	0.95873	0.49079	0.40987	
isi5	2.74359	2.72222	1.45884	1.12063	0.21667	0.93551		nccp5	3.12821	3.16667	1.21997	0.82857	0.12536	0.87035	
isi6	2.66667	2.83333	1.01754	0.71429	0.14665	0.44251		pqc1	3.41026	3.25000	0.77463	1.16429	0.11024	0.48173	
cwc1	3.51282	3.63889	0.67746	0.75159	0.37602	0.52032		pqc2	3.82051	3.83333	0.57220	1.05714	0.03302	0.95086	0.9514749
cwc2	3.61538	3.72222	0.71660	0.66349	0.41056	0.57989		pqc3	3.33333	3.30556	0.85965	0.96111	0.36725	0.89999	
cwc3	2.64103	2.47222	1.18354	0.94206	0.24899	0.48194		pqc4	3.02564	3.05556	0.97301	0.85397	0.34970	0.89279	
cwc4	3.38462	3.27778	0.87449	0.89206	0.47441	0.62423		pqc5	3.17949	3.16667	0.83536	0.94286	0.35658	0.95319	
cwc5	2.84615	2.69444	0.71255	1.01825	0.14131	0.48109		iis	3.20513	3.13889	0.85155	0.69444	0.27245	0.74589	
cwc6	2.87179	2.69444	0.95682	0.78968	0.28443	0.41515		wcf1	2.82051	2.66667	0.83536	0.97143	0.32377	0.48527	
qrks1	3.64103	3.55556	0.55196	1.05397	0.02646	0.67910	0.6831023	wcf2	2.56410	2.47222	0.77868	0.99921	0.22592	0.67375	
qrks2	3.30769	3.00000	1.06073	0.80000	0.20100	0.17295		wcf3	2.94872	2.72222	0.52362	0.94921	0.03737	0.25439	0.260433
qrks3	3.46154	3.41667	0.62348	0.93571	0.11108	0.82587		wcf4	2.89744	2.77778	0.67341	0.92063	0.17309	0.56252	
qrks4	3.17949	3.11111	0.88799	0.95873	0.40733	0.75887		wcf5	3.00000	2.75000	0.68421	0.76429	0.36825	0.20725	
qrks5	3.07692	3.00000	0.75709	0.80000	0.43255	0.70696		wcf6	3.05128	2.75000	0.68151	1.10714	0.07258	0.17021	
qrc1	3.28205	3.16667	0.73414	0.65714	0.37174	0.55177		perm1	3.76923	3.83333	0.55061	0.48571	0.35536	0.70150	
qrc2	3.53846	3.58333	0.57085	0.87857	0.09751	0.81946		perm2	3.69231	3.66667	0.53441	0.62857	0.31161	0.88454	
qrc3	3.17949	3.13889	0.57220	0.69444	0.27918	0.82558		perm3	3.58974	3.63889	0.93252	0.58016	0.07971	0.80843	
qrc4	3.25641	3.47222	0.61673	0.77063	0.25057	0.26483		perm4	3.64103	3.69444	0.92038	0.84683	0.40325	0.80663	
qrc5	3.17949	3.16667	0.57220	0.94286	0.06693	0.94910		perm5	3.53846	3.86111	0.83401	0.40873	0.01780	0.08283	0.0790151
misf1	3.33333	3.11111	0.91228	0.78730	0.33125	0.30111		perm6	3.56410	3.83333	0.83131	0.42857	0.02528	0.14910	0.1441873
misf2	3.20513	3.08333	0.79892	0.76429	0.44898	0.55316		perm7	3.56410	3.72222	0.83131	0.60635	0.17428	0.42382	
misf3	3.20513	3.11111	0.79892	0.84444	0.43222	0.65476		perm8	3.51282	3.77778	0.94062	0.57778	0.07430	0.19455	
misf4	3.10256	3.16667	0.72605	0.60000	0.28574	0.73487		perm9	3.12821	3.61111	0.90418	0.70159	0.22555	0.02281	
misf5	3.12821	3.08333	0.69366	0.76429	0.38386	0.82058		Summary items nccp3 and perm 9 show significant mean difference							

Table 4-2 Summary of the non-response bias test

4.7. Summary

This chapter presented the method, statistical techniques, the population and the variables used in this research. One of the points to note is that RM employees have a set of skills that include literacy in information system tools. Additionally, because of the kind of work that they perform, in general, there are some other skills related to managing figures, performing quantitative analysis and producing reports that involve different risks and different risk levels of decisions. The decision to survey this population is appropriate because this type of respondent gives value to structured tools of gathering data and the questionnaire worked properly for them.

This chapter has covered the research methodology. The first part identified the sample and the variables used in particular indicating the transformation required for a better measure of the variable through the scores of the items. It described the use of descriptive statistics and regression models to identify the relationships of the variables in order to test the hypotheses. Equally, it indicated the importance of tests for the reliability and validity of the variables and for supporting the size and the criteria to assess models through power analysis.

In the next chapter there is a presentation of the results of the research. The sections have been divided into the results coming from exploratory data analysis and those from multivariate analysis.

5. Chapter Five Findings and hypothesis testing

In the previous chapter the basis of the research, population variables and concepts to support the research results were presented. In this chapter, the results are presented based on the hypothesis testing. The following sections include the exploratory data analysis (Section 5.1) and the multivariate analysis (Section 5.2) concluding with a summary of the hypothesis testing. Statistical software (SAS® version 9.1.3) was used to manage the data, to test the hypotheses and to search for relationships between the variables. Each hypothesis was tested in the form of the null hypothesis: there was no association between the variables and a one-tailed test carried out. The level of significance used was α=5% (Moore and McCabe 1999).

5.1. Exploratory Data Analysis

Exploratory data analysis (Berry and Linoff, 1997; Parr, 2001; Dunham, 2003) is a set of statistical techniques for analysing data. It includes graphical and quantitative techniques. The data analysis was performed using: the Cronbach's Alpha coefficients (Section 5.1.1) in order to discover the consistency of the items in each variable, a summary of statistics of the variable attributes and distribution analysis (Section 5.1.2), demographic distributions review (Section 5.1.3), and a correlation analysis to measure the association of the variables (Section 5.1.4).

5.1.1. Analysis of Cronbach's alpha coefficients

The Cronbach's alpha coefficients show the degree of association between variables and items. The items used in each variable describe the concept of the variable used. The results are all above 0.7 which is the threshold to be used in the analysis (Cortina, 1993, Hair et al., 2003). The highest values of the indicator are for the web channel functionality and perceived value of the ERM implementation. Variables, items and Cronbach's alphas are shown in Table 5-1. The internal consistency of the constructs indicates a reliable scale for all the variables.

Variable	Items	Cronbach's alpha
Organisational capacity for work coordination (cwc)	• The organisation encourages interdisciplinary work • The organisation encourages interdepartmental work • There are good web based collaboration tools • People are willing to work with multiple groups • There are guiding principles for working with different groups • There are standards for using collaboration tools	Score index of six items, each measured on a 5-point scale (Cronbach's alpha 0.80)
Perceived quality of communication among people (pqc)	• The communication between the Risk Management groups is good • The communication within my Risk Management group is good • The communication environment fosters the interchange of different points of view • There is a good capacity to get conclusions easily during meetings • The communication environment promotes team work	Score index of five items, each measured on a 5-point scale (Cronbach's alpha 0.88)
Perceived quality of risk control (qrc)	• The risk mitigation tools are good • The risk assessment process is good • The risk transfer process is good • The risk product evaluation is good • The risk aggregation analysis is good	Score index of five items, each measured on a 5-point scale (Cronbach's alpha 0.86)
Web channel functionality (wcf)	• The Risk Management Intranet provides access to collaboration tools • The Risk Management Intranet provides access to all applications used in risk management • The Risk Management Intranet provides access to the proper data • The Risk Management Intranet facilitates interaction in problem solving process • The Risk Management Intranet supports communication among risk management people • The Risk Management Intranet supports risk management controls	Score index of six items, each measured on a 5-point scale (Cronbach's alpha 0.92)
Risk Management Information systems functionality (misf)	• The systems provide support to the risk modeling process • The systems provide access to experience in risk analysis • The systems provide adequate data management support • The systems provide capacity to improve work flow • The systems provide capacity to work with multiple groups on a project	Score index of five items, each measured on a 5-point scale (Cronbach's alpha 0.88)
People's interaction for Information system design(iis)	• Perceived quality of people interactions in the ERMIS design	This is only one item
Perceived quality of risk knowledge sharing (qrks)	• People are willing to share risk knowledge • The availability of documentation is good • The access to experience is good • There is an appropriate environment to discuss results interdepartmentally • There is an appropriate environment for the creation of shared solutions	Score index of five items, each measured on a 5-point scale (Cronbach's alpha 0.79)
Perceived value of information systems integration (isi)	• The same standards are used • A common data structure is used • A common data-warehouse is used • A common user interface is used • A common report system is used • A common application access is used	Score index of six items, each measured on a 5-point scale (Cronbach's alpha 0.89)
Quality of network capacity for connecting people (nccp)	• There is an enterprise portal structure supporting interdepartmental work • There are collaboration tools easily available • People use web based workspaces for working on projects • Solutions are created because of multidepartment work • Sharing my work with others is easy	Score index of five items, each measured on a 5-point scale (Cronbach's alpha 0.86)
Perceived value of ERM (perm)	• ERM improves collaboration • ERM promotes our experience sharing • ERM reduces the number of times we reinvent the wheel • ERM improves the quality of data • ERM improves our interdisciplinary work • ERM improves our interdepartmental work • ERM improves our understanding of model results • ERM improves our problem solving process • ERM improves our capacity of mathematical modeling	Score index of nine items, each measured on a 5-point scale (Cronbach's alpha 0.93)

Table 5-1 Cronbach's alpha test of the items per variable

The variable *qrks* has the lowest Cronbach's alpha value, at 0.79, even though this is over the 0.7 threshold. A review of Table 5-2 indicates that none of the items will increase the alpha value, if the item is removed. The raw variables alpha are all above 0.7 (Hair et al., 2003) to ensure the reliability of the construct and no value of the deleted item is greater than the Cronbach's alpha of the variable (0.79) suggesting that all the items are used keeping the overall reliability of the variable. This means that the scale for this variable is reliable using the selected items and can be used in this research.

Cronbach Coefficient Alpha with Deleted Item		
	Raw Items	
Deleted Variable	Correlation with total	Alpha
qrks1	0.55	0.77
qrks2	0.62	0.76
qrks3	0.71	0.75
qrks4	0.79	0.74
qrks5	0.66	0.76
qrks	1	0.79

Table 5-2 Cronbach's Alpha for the variable qrks

5.1.2. Summary Statistics and Distribution Analysis

The summary statistics of the variables (See Table 14) allows the observation of the basic attributes of the data. The variables have the following characteristics:

A first element to note is that these variables have mean equal to zero because of the way they were built (See Section 3.3). A second point to mention is that the variables have low kurtosis (lower than 1) representing that the variable distributions are flat with central peaks lower and broader than a normal distribution, and tails shorter and thinner. The only exception is the variable *perm* that has a kurtosis of 3.047. The skewness is generally close to zero, representing symmetry. However, the variables *pqc, misf* and *perm* are the only ones that have skewness out of the range -0.5 and +0.5 range indicating lower symmetry.

In summary, variables were built with a mean zero and the difference between the median and the mean is higher for the variables: management information system functionality *misf* and web channel functionality *wcf*. Variables are in most cases skewed left (negative skewness value), what means most of the values are located to the right of the mean, except *isi* and *qrc* which have positive skewness or more values located to the left of the mean. The negative values of skewness indicate that people assigned, in some cases, higher values when answering the questionnaire. The higher value means a higher agreement with the item used in the survey.

After the review of the main statistics of variables, the next step is to analyse if the variables are following a normal distribution. This is important in order to satisfy the normality assumption in the correlation analysis. For this analysis, three different approaches were used: analysis of the descriptive statistics, analysis of the Q-Q Plots and probability plots and formal tests of normality.

Concept	isi	cwc	qrks	pqc	misf	nccp	iis	wcf	perm	qrc
Mean	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Standard Error	0.440	0.384	0.334	0.375	0.375	0.362	0.091	0.458	0.652	0.364
Median	0.103	0.164	0.466	0.564	1.039	-0.117	-0.262	0.849	0.585	0.006
Mode	-4.355	2.306	3.644	2.742	4.301	1.752	0.871	-5.557	4.257	3.437
Standard Deviation	4.838	4.227	3.674	4.129	4.127	3.981	1.000	5.039	7.167	4.001
Sample Variance	23.409	17.864	13.502	17.052	17.036	15.848	1.000	25.394	51.370	16.011
Kurtosis	-0.658	0.505	-0.723	0.724	0.182	-0.220	-0.588	0.029	3.047	-0.393
Skewness	0.009	-0.207	-0.313	-0.722	-0.654	-0.116	-0.252	-0.297	-0.791	0.055
Range	21.426	23.390	15.134	21.011	20.036	19.597	4.531	24.576	46.770	17.413
Minimum	-9.711	-11.645	-8.185	-12.756	-11.544	-9.060	-2.528	-11.963	-30.821	-8.172
Maximum	11.714	11.745	6.950	8.254	8.492	10.537	2.003	12.613	15.949	9.241
Sum	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Count	121	121	121	121	121	121	121	121	121	121

Table 5-3 Descriptive statistics of the variables

First, a descriptive analysis is based on the summary statistics of the raw data (Table 5-3): The median should be close to the mean in order to have a good fit of the distribution to the normal one. *isi, cwc, qrc, nccp* are the variables where the difference is the lowest with regard to the mean. The other variables *qrks, pqc, iis, perm*, have higher differences from zero, in particular *misf*, *wcf* present the highest difference from the general mean.

The skewness value for the normal distribution is zero; meanwhile, the kurtosis should be close to three (Klugman et al., 1998). The high value in the Kurtosis (Klugman et al., 1998) is an indicator of variables with thin tails and higher peaks compared to the normal distribution.

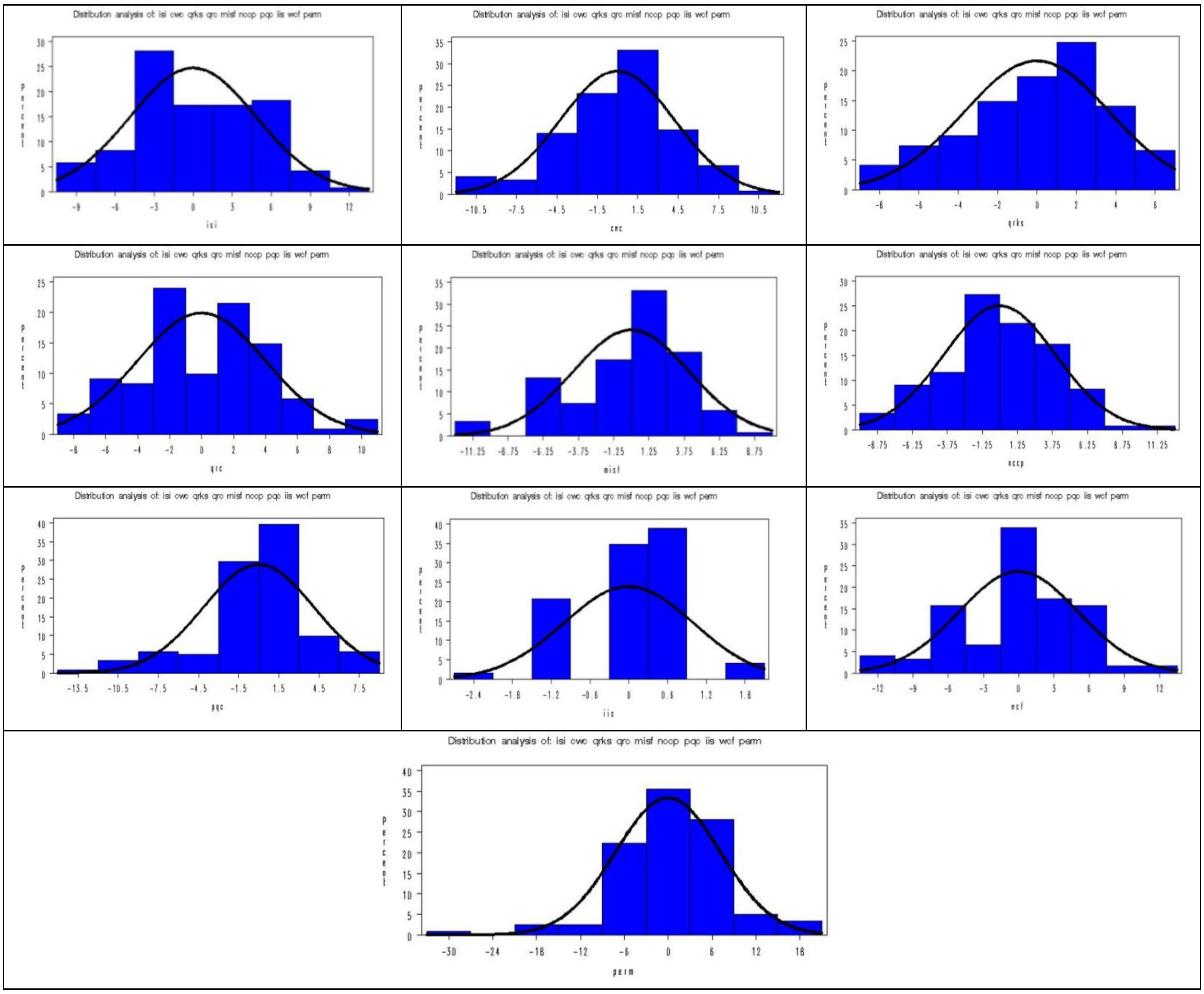


Figure 5-1 Histograms Variable distribution

As mentioned, the mean and median were not coincident for the variables. However, the skewness value was close to zero and the difference between mean and median was not too high. In summary, from the observation of the descriptive statistics it is observed that only *isi, cwc*, *nccp*, and *qrc* follow a normal distribution.

Second, the analysis based on a review of the histograms (Figures 5-1) and Q-Q plots (Figure 5-2) show that the sample distribution is not very different from the normal distribution, except the variable *iis.* Because of the definition of this variable, it behaves as a discrete variable. Third, an analysis of the formal normality test was performed. The application of the Kolmogorov-Smirnov Test of normality (See Table 5-4) indicates that the variables *cwc, qrc, nccp* are those where the null hypothesis of normality cannot be rejected (H_o the normal distribution). For the other variables *isi, qrks, misf, pqc, iis, wcf* and *perm* the null hypothesis H_o , is rejected.

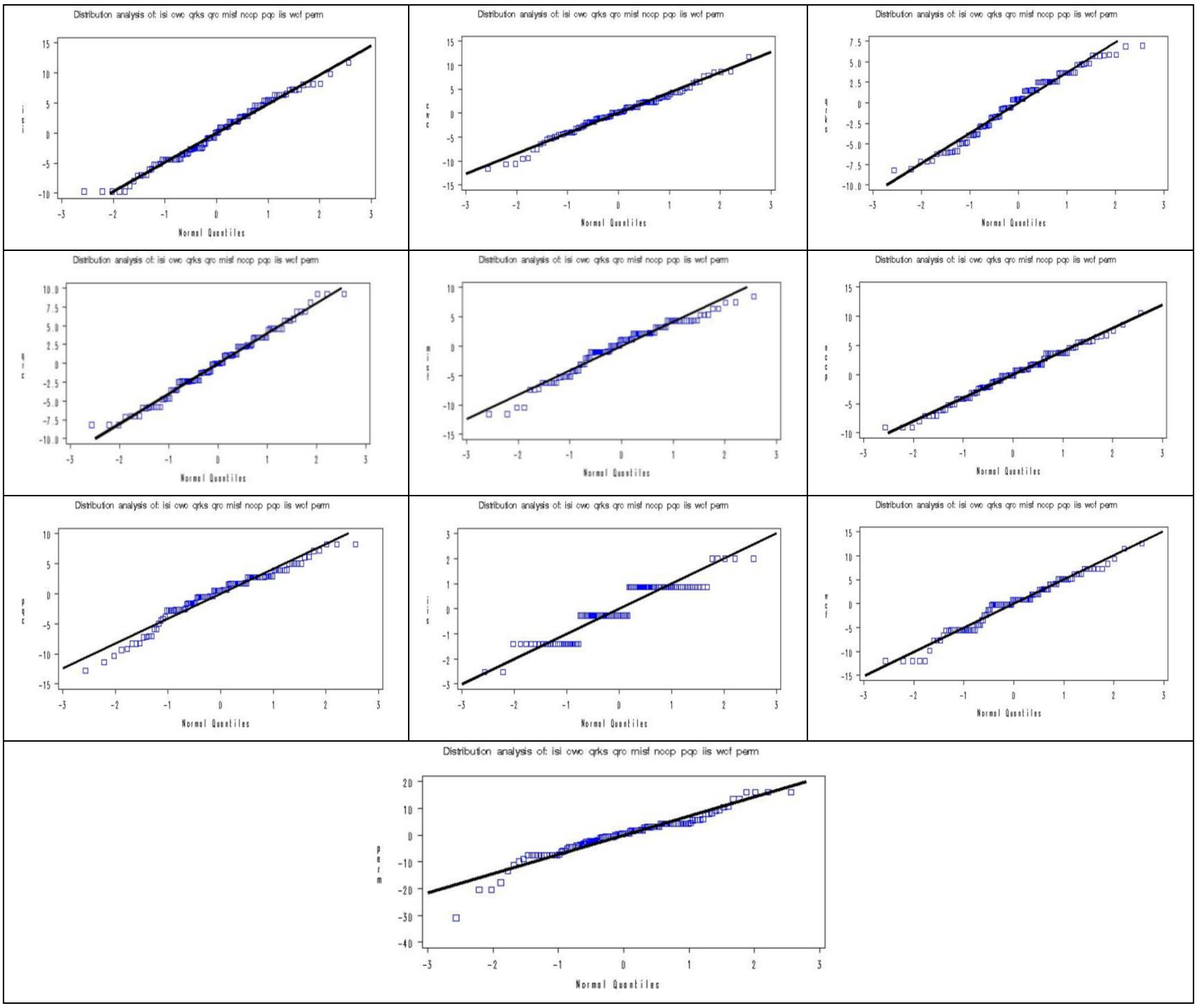


Figure 5-2 QQ-Plots for evaluation of normality

The non-normal distribution for some of the variables could affect the correlation analysis when the correlation analysis uses Pearson’s coefficient, which assumes the normality of the population for the variables that are analysed. However, Hair et al. (2003) indicate that, “since correlation is considered a reasonable robust statistic when the distribution varies from normal, this assumption is frequently taken for granted.” The multivariate analysis presented in the section 5.2 will not be affected in case that some variables do not follow the normal distribution because the multiple regression model does not have the normality of variables assumption as part of the model definition (See Section 4.6).

Komogorov-Smirnov Test			
Variable	D-Statistics	p-value	Normal
ISI	0.0862	0.025	No
CWC	0.0671	>0.150	Yes
QRKS	0.1054	<0.010	No
QRC	0.0673	>0.150	Yes
MISF	0.1263	<0.010	No
NCCP	0.0734	0.107	Yes
PQC	0.1161	<0.010	No
IIS	0.2378	<0.010	No
WCF	0.1572	0.010	No
PERM	0.1179	0.010	No

Table 5-4 Goodness of fit for normality research variables

5.1.3. Demographic Distributions Review

The review of the demographic groups was performed in two ways: first, a cross variables analysis indicating the main groups and attributes of the group's distribution; second, reviewing, using ANOVA, the significance of the differences of the group's means and variances.

The first analysis of the group's distribution, Appendix 9.3,Tables 9-5 and 9-6 show the distribution of answers according to the demographic variables: risk management area, risk management process, time of experience in risk management and time in the position of risk management. These tables indicate the cross tabulation of the variables and their categories. Table 9-5 presents the frequency values and Table 9-6 shows the crossed percentages relative to the total number of points in each category of each variable.

Risk management area (See Figure 2-4 for an example of RM organisation) is the description of the risk management group which the respondent belongs to. Seven categories were used in the survey. The concentration in the sample is in the groups of credit risk (39%) and market risk (31%). This represents 70% of the sample, as would be expected since these are the biggest groups in financial institutions. The smallest groups correspond to the legal/regulatory risk and currency risk with 2% and 1% respectively. Again, this is to be expected.

In the groups based on RM experience, the concentration is on those who have more than five years of RM experience representing 62%. From these experienced people, the concentration is on the Credit Risk (above 30%) and Market Risk (above 35%).

Regarding the RM processes, risk quantification and risk evaluation concentrate (63%) on most of the respondents as expected because of the weight that these activities have in RM practice. As previously stated, the concentration is on the credit and market risk areas, for the risk processes 80% is for risk quantification and 79% for the risk evaluation. Concerning the groups based on the number of years in the position, the concentration is on the group of 1 to 5 years, representing 65%.

Upon reviewing the crossed statistics some points of analysis appear. The group of the credit risk has 62% of its members in the groups with more than 5 years of experience, 70 % concentrated on the risk quantification and risk evaluation processes. Regarding the time in the position, the groups connected with credit and market risk are concentrated on the 1 to five year range. Additionally, the group of RM experience of people with more than 5 years, has not been in the same position, that is more than 70% of people with 5 to 10 years of experience has been less than 5 years in the position. Concerning those with 10 or more years of experience more than 70% have been less than five years in the position. In particular, 42% of the people who have more than 10 years of experience are in credit risk.

The years of experience for the risk quantification variable are concentrated on more than 5 years (62%), the same as risk evaluation where the percentage reached 69%. The number of years in the position for people in risk quantification is between 1 to 5 years, 66% and for risk evaluation 55% in the same group of 1 to 5 years. The group of people between 1 and 3 years in the position represents the 64% of the people with more than 5 years of risk management experience; however, 83% of people with 3-10 years of experience are in the group of 3-5 years in the position.

For the second analysis of the groups the ANOVA technique was used to examine whether the means and variances differed between groups. Tables 5-5 and 5-6 indicate the results. The significance level used was 5%. The results of the Levene F-test indicate that the hypothesis of equal variances is accepted for all variables and all the groups (Table 5-6).

For all the groups the hypothesis of equal means was accepted except in two cases. The RM processes group, has a significant difference between group 1 (Risk identification) and 6 (Risk evaluation) in the variable *qrks* The mean value in the group of risk identification is -2.6, showing lower agreement with the items of the *qrks* variable than in the group of risk evaluation where the value is 1.04. The variable *pqc* has a p-value smaller than 5% but Tukey's test shows a significant difference between the groups of less than 1 year of experience and those with more than 5 years and less than 10 years of experience groups (See Table 5-5). The means difference does not affect the regression assumptions.

Anova F-test Tukey -Test Equal Means				
p-value	rmarea	rmprocess	timeposition	rmexperience
isi	0.895	0.321	0.400	0.907
cwc	0.716	0.019	0.206	0.899
qrks	0.490	0.024	0.323	0.356
qrc	0.672	0.576	0.405	0.293
misf	0.622	0.178	0.313	0.643
nccp	0.777	0.084	0.460	0.286
pqc	0.962	0.110	0.052	0.045
iis	0.993	0.083	0.306	0.953
wcf	0.933	0.305	0.259	0.372
perm	0.278	0.585	0.573	0.350

Significance level 5%
QRKS differences between groups 1 and 6
PQC difference groups 1 and 4

Table 5-5 ANOVA p-values report for significance analysis of mean differences

Anova F-Test Levene test Equal Variances				
p-value	rmarea	rmprocess	timeposit	rmexperience
cwc	0.918	0.517	0.769	0.984
isi	0.908	0.198	0.310	0.442
qrks	0.829	0.934	0.593	0.457
qrc	0.794	0.842	0.799	0.742
misf	0.610	0.899	0.880	0.203
nccp	0.728	0.278	0.426	0.281
pqc	0.828	0.170	0.301	0.175
iis	0.450	0.253	0.677	0.452
wcf	0.888	0.547	0.298	0.829
perm	0.305	0.919	0.667	0.583

Significance level 5%

Table 5-6 ANOVA p-values report for significance analysis of variance differences

The summary of the ANOVA indicates that the groups in general for all variables have no significant variance difference between them and only two groups for two variables had a significant mean difference. To complement the descriptive statistics review the analysis requires other metrics to see the grade of association for the whole sample and population. For this reason the next sections present the correlation analysis and the multiple regression models.

5.1.4. Correlation Analysis

The correlation analysis for all variables was performed. The individual correlation was tested in order to identify, mainly, the level of association of the KM variables and the dependent variables. The correlation analysis using the Pearson coefficient assumes normality of the variables. As discussed in section 5.1.2, some variables are not normally distributed and Hair et al. (2003) pointed out that correlation takes the normality assumption for granted. Thus, two correlation coefficients were calculated, Pearson's Coefficient and the non-parametric Spearman's coefficient, and the test for the significance applied to both.

Pearson's coefficient uses continuous variables as they do in this study. Table 5-7 shows the significant correlation coefficients at 5%, 1% and 0.1%.

Pearson Correlation Coefficients, N = 121										
Prob > |r| under H0: Rho=0										
	cwc	pqc	iis	qrks	misf	wcf	isi	nccp	qrc	perm
cwc	1.000	0.58233***	0.47241***	0.65362***	0.53092***	0.54025***	0.35871***	0.68867***	0.64049***	0.22046*
pqc	0.58233***	1.000	0.53637***	0.56898***	0.38632***	0.33039***	0.119	0.48914***	0.56058***	0.29994**
iis	0.47241***	0.53637***	1.000	0.42727***	0.44578***	0.26711**	0.156	0.43425***	0.4365***	0.27861**
qrks	0.65362***	0.56898***	0.42727***	1.000	0.60198***	0.40319***	0.2409**	0.59556***	0.64633***	0.20937*
misf	0.53092***	0.38632***	0.44578***	0.60198***	1.000	0.56131***	0.41682***	0.63513***	0.60975***	0.146
wcf	0.54025***	0.33039***	0.26711**	0.40319***	0.56131***	1.000	0.53497***	0.53273***	0.57567***	0.031
isi	0.35871***	0.119	0.156	0.2409**	0.41682***	0.53497***	1.000	0.40242***	0.40061***	-0.114
nccp	0.68867***	0.48914***	0.43425***	0.59556***	0.63513***	0.53273***	0.40242***	1.000	0.56599***	0.157
qrc	0.64049***	0.56058***	0.4365***	0.64633***	0.60975***	0.57567***	0.40061***	0.56599***	1.000	0.172
perm	0.22046*	0.29994**	0.27861**	0.20937*	0.146	0.031	-0.114	0.157	0.172	1.000
	*	Significant at 0.05								
	**	Significant at 0.01								
	***	Significant at 0.001								

Table 5-7 Individual Correlations of all variables significance level indicated

First, the correlation coefficient of the dependent variables shows no significant association between *qrc* and *perm*. This lack of association of the two variables *qrc* and *perm* allows the differentiation of the models that have been used in this research and justifies treating them as two different RM concepts in the analysis.

Second, the analysis of the dependent variable correlations with the independent variables. For the quality of risk control *(qrc)* variable, all eight correlation coefficients are significant at the p=0.001 level, and all coefficients are positive. The highest correlations are with the variables quality of risk knowledge sharing (Pearson 0.65, Spearman 0.64), and perceived capacity for work coordination (Pearson 0.64, Spearman 0.62).

Regarding the correlations to perceived value of ERM (*perm*), four variables are significantly correlated and all these coefficients are positive. These variables are: interaction for information system design, perceived quality of communication among people (both significant at p=0.01), perceived quality of risk knowledge sharing and capacity for work coordination (both significant at p=0.05), The correlation coefficients for these variables with *perm* are all under 0.30 indicating a weaker association of the variables with *perm* than with *qrc*. The other four variables are not significantly correlated with *perm*, and indeed for perceived value of information systems integration and web channel functionality, the coefficient appears to be negative.

None of the correlations among the independent variables is above 0.7 which is the threshold to take note of (Hair et al., 2003) in the analysis of multicollinearity (See Section 5.2.2.6).

Given the non-normal distribution of some of the variables, the Spearman's Coefficient was calculated. The Spearman's coefficient provides a non parametric correlation metric of the correlation for ordinal variables and does not assume normality for the calculation. The t-test is used for identifying the significance. The variables can be considered ordinal given the construction performed on them and described in section 4.3.

Spearman Correlation Coefficients, N = 121 Prob > |r| under H0: Rho=0										
	cwc	pqc	iis	qrks	misf	wcf	isi	nccp	qrc	perm
cwc	1	0.53522***	0.44956***	0.64117***	0.49971***	0.47761***	0.37246***	0.68887***	0.61797***	0.18137*
pqc	0.53522***	1	0.53892***	0.57959***	0.41088***	0.28794***	0.10402	0.45073***	0.53377***	0.27389**
iis	0.44956***	0.53892***	1	0.43134***	0.42321***	0.22159*	0.14778	0.39406***	0.40347***	0.25069**
qrks	0.64117***	0.57959***	0.43134***	1	0.56558***	0.36763***	0.23601**	0.55738***	0.64337***	0.20829*
misf	0.49971***	0.41088***	0.42321***	0.56558***	1	0.59586***	0.38091***	0.55309***	0.57992***	0.08741
wcf	0.47761***	0.28794***	0.22159*	0.36763***	0.59586***	1	0.50363***	0.49624***	0.53834***	-0.05781
isi	0.37246***	0.10402	0.14778	0.23601**	0.38091***	0.50363***	1	0.39048***	0.38709***	-0.14987
nccp	0.68887***	0.45073***	0.39406***	0.55738***	0.55309***	0.49624***	0.39048***	1	0.51467***	0.01827
qrc	0.61797***	0.53377***	0.40347***	0.64337***	0.57992***	0.53834***	0.38709***	0.51467***	1	0.1285
perm	0.18137*	0.27389**	0.25069**	0.20829*	0.08741	-0.05781	-0.14987	0.01827	0.1285	1
	*	Significant at 0.05								
	**	Significant at 0.01								
	***	Significant at 0.001								

Table 5-8 Spearman's Correlation Coefficient

Table 5-8 shows that the variable correlations which are significant are the same as the Pearson's coefficients showed. This means the correlation review indicates that all variables are correlated at 5% except the couples: *pqc-isi*, *iis-isi* and *misf-perm*, *wcf-perm, isi-perm, nccp-perm, qrc-perm*, which do not have significant correlation.

In summary, correlations show that those variables that are connected to people and processes are significantly positive correlated to perceived quality of risk control and perceived value of ERM. The highest positive correlation is between *qrks* and qrc.. Meanwhile, the correlations of the technology variables are positively significant only with *qrc* and not with *perm*.

A review of Tables 5-7 and 5-8 showed individual correlations that suggest the support of some of the hypotheses from a bivariate analysis; however, the main method of testing the hypotheses is based on the results of the multivariate analysis described in the next section 5.2., because of the reality of the interaction and correlation of variables in RM actions.

5.2. Multivariate Analysis: Regression Diagnostic

This section presents the results of the multiple and stepwise regressions that were performed using the 121 responses and the two dependent variables: perceived quality of risk control and perceived value of ERM implementation. The next sections include a validation of the multiple regression assumptions by dependent variable, the results of multiple regression models and stepwise regression models, and the analysis of the stepwise models using the groups of demographic variables.

5.2.1. Multiple Regression Assumptions

In this section, the assumptions of the multiple regression model are analysed based on the work of Hair et al. (1998) as presented in Section 4.6:

- Linearity of the relationship between independent and dependent variables
- Homoscedasticity: Equality of variance of the errors
- No autocorrelation of the errors and independence of observations
- Normality of the residuals or errors
- No multicollinearity
- No outlier distortion

The regression models used (*p+1*) random variables, which are the explanatory variables (*p*=8) and the dependent variable and 121 observations. The values of the X_i random variables (See model structure Section 4.6) are fixed as the observed values in order to perform the model. Two different models were analysed, one per each dependent variable identified here as the QRC and PERM models. A p-value of 5% was used as the threshold for deciding the significance of the coefficients of the variables in each model. The following are the analyses performed to review the assumptions:

5.2.1.1. Linearity of the relationship between independent and dependent variables

Hair et al. (1998) pointed out, “Linearity is easily examined through residual plots.” Additionally, these authors indicated, “Any consistent curvilinear pattern in the residuals indicates that corrective action will increase both the predictive accuracy of the model and the validity of the estimated coefficients.” There are no curvilinear patterns that would indicate a non linear relationship between independent variable and dependent variables either for QRC or for PERM (See Figures 5-3 and 5-4).

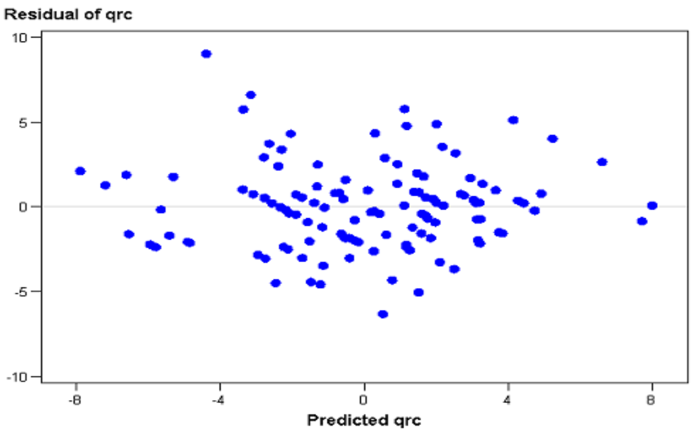


Figure 5-3 Residual vs. Predicted QRC model

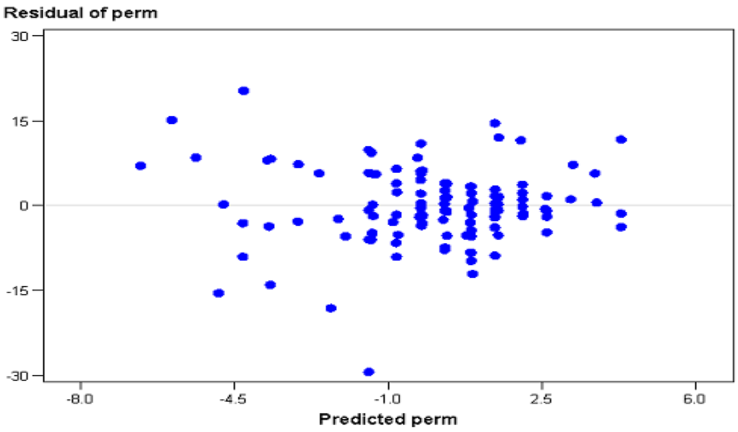


Figure 5-4 Residual vs. Predicted PERM model

5.2.1.2. Homoscedasticity: Equality of variance of the errors

One of the assumptions in the multivariate regression model is the similarity of the variances of the errors. The White test for the two models was applied and the homoscedasticity assumption (Table 5-9) is accepted at 5% significance level.

QRC Model			PERM Model		
Test of First and Second Moment Specification			Test of First and Second Moment Specification		
DF	Chi-Square	Pr > ChiSq	DF	Chi-Square	Pr > ChiSq
44	42.09	0.5537	44	46.26	0.3792

Table 5-9 Test for variance equality for QRC and PERM Models

5.2.1.3. No autocorrelation of the errors and independence of observations

Neither the model for QRC nor the model for PERM has problems with the autocorrelation assumption. For the model QRC the Durbin-Watson test statistics is 1.903 and for the model PERM the Durbin-Watson is 2.112, both in the ranges that indicate independence. (Table 5-10).

Durbin-Watson	Statistics	1st Order Correlation
QRC Model	1.903	0.048
PERM Model	2.112	-0.059

Table 5-10 Durbin-Watson for QRC and PERM models

5.2.1.4. Normality of the residuals or errors

QRC Model Residuals Normality Analysis

The analysis of the residual plots (Figure 5-5) shows the residuals by variable. The graphs of the residuals by variable in the QRC model do not show any particular pattern that suggests the need to transform variables. In general the graphs indicate that the distribution of points is symmetric relative to the mean of the *qrc* variable. In some cases there is an indication of points that are more separated than others, suggesting possible outliers, but not creating a pattern that affects the analysis.

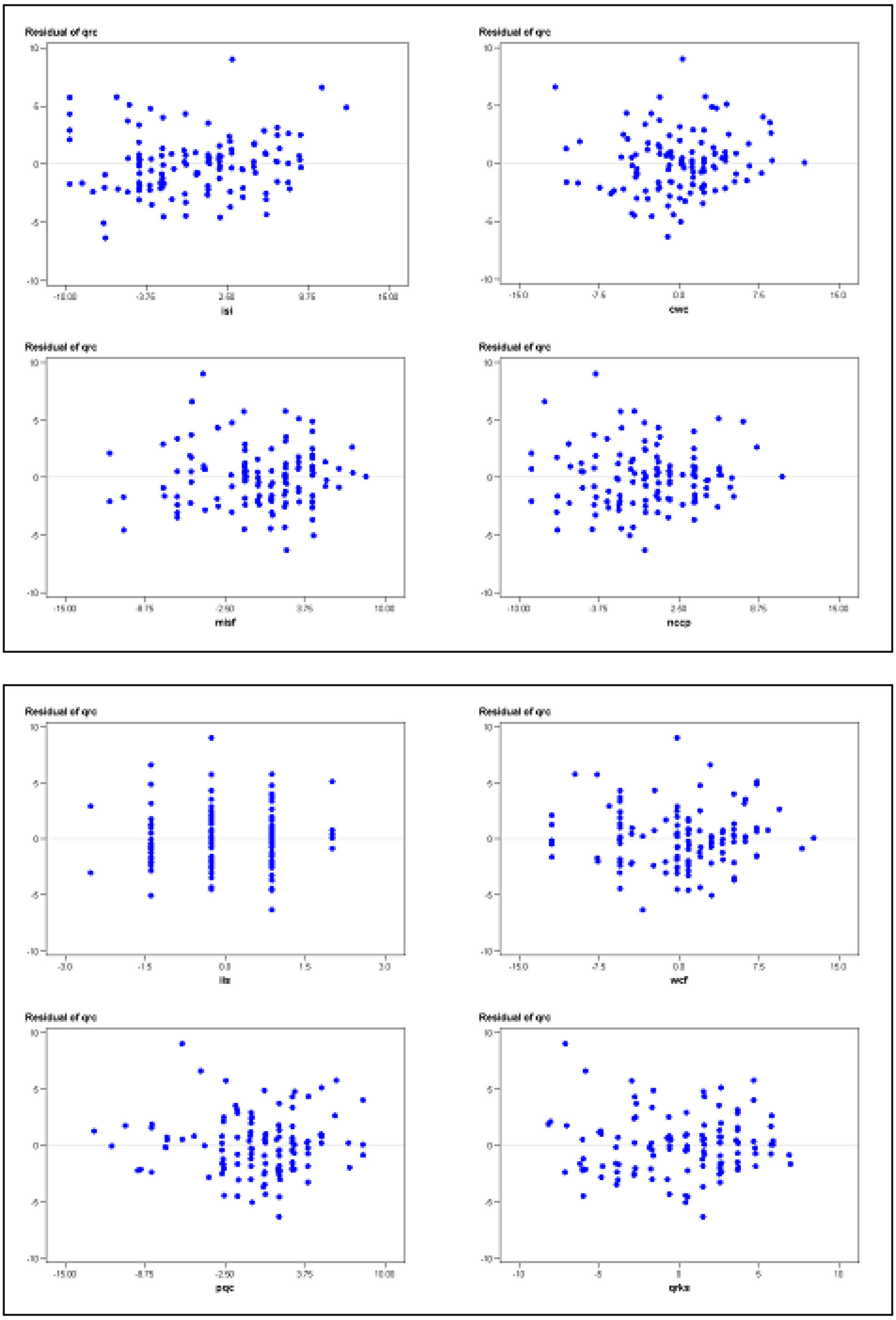


Figure 5-5 Residuals on the QRC Model

Thus, for the QRC model, the residuals show a consistent cloud of points with a balanced data distribution without a shape that could indicate that the residuals follow a different statistical distribution from a normal one. Figure 5-6 shows the histogram of

QRC residuals suggesting that the distribution of the points to the right and left of the median is similar and there is no evidence of skewness to the right or to the left. Table 5-11 indicates that median and mean are not far apart; they are close to zero and the skewness is near to zero as well.

residqrc		residperm	
Mean	1.58E-16	Mean	1.47E-16
Standard Error	0.090909	Standard Error	0.090909
Median	-0.09367	Median	-0.06106
Mode	#N/A	Mode	#N/A
Standard Deviation	1	Standard Deviation	1
Sample Variance	1	Sample Variance	1
Kurtosis	0.793391	Kurtosis	3.280302
Skewness	0.59963	Skewness	-0.39053
Range	5.464557	Range	7.454772
Minimum	-2.29315	Minimum	-4.50952
Maximum	3.171411	Maximum	2.945254
Sum	1.91E-14	Sum	1.78E-14
Count	121	Count	121

Table 5-11 Descriptive statistics of the residuals for the two models

The quantile plots (Figure 5-6)) shows that the points are not separated from the normal line; there are some differences in the tails but the majority of the points are close to the normal line.

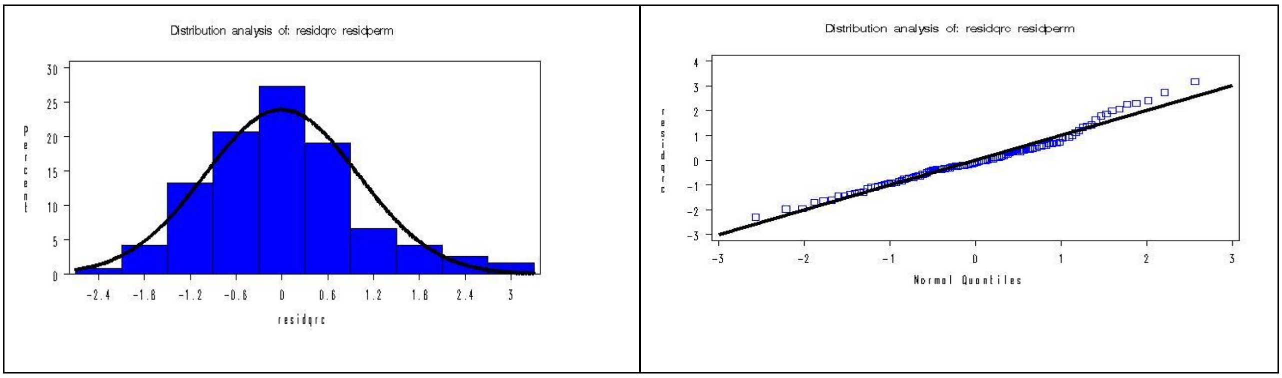


Figure 5-6 Graphic Normality tests for residuals of QRC Model. Histogram and QQ-Plot Normality

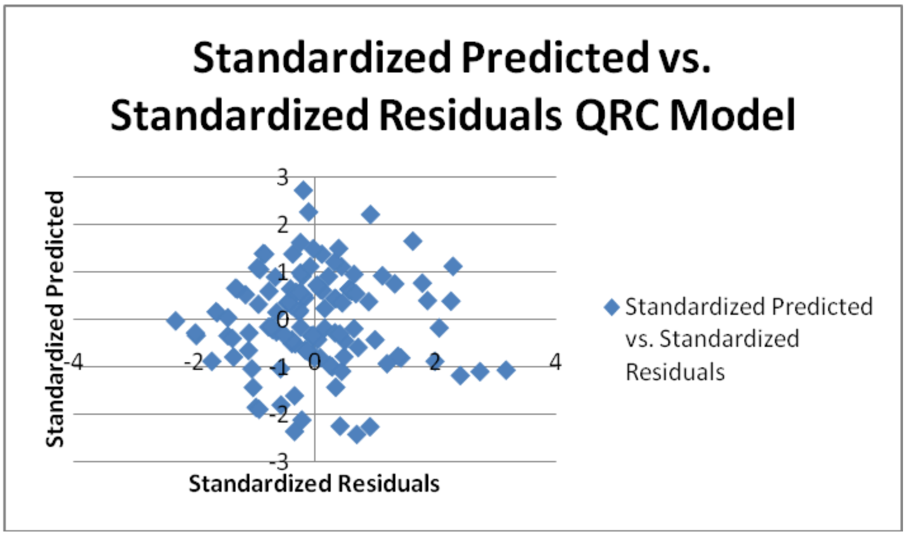


Figure 5-7 Standardized Predicted vs. Standardized Residuals QRC Model

Additionally, the standardized predicted and residuals plot (Figure 5-7) shows 8 of 121 some points are outside the range -2, 2, which represents 93% of the cases inside the limits specified by Hair et al. (2003). However, Hair et al. (2003) continue saying: "By examining the information shown in all three plots we conclude there are not significant data problems that would indicate the multiple regression assumptions have been seriously violated. This conclusion is reinforced by the fact that regression is considered a "robust" statistical technique where violations of the assumptions must be substantial before we encounter problems." Our case is similar, thus from the graphical analysis of the residuals it seems reasonable to conclude that the QRC model residuals follow a normal distribution.

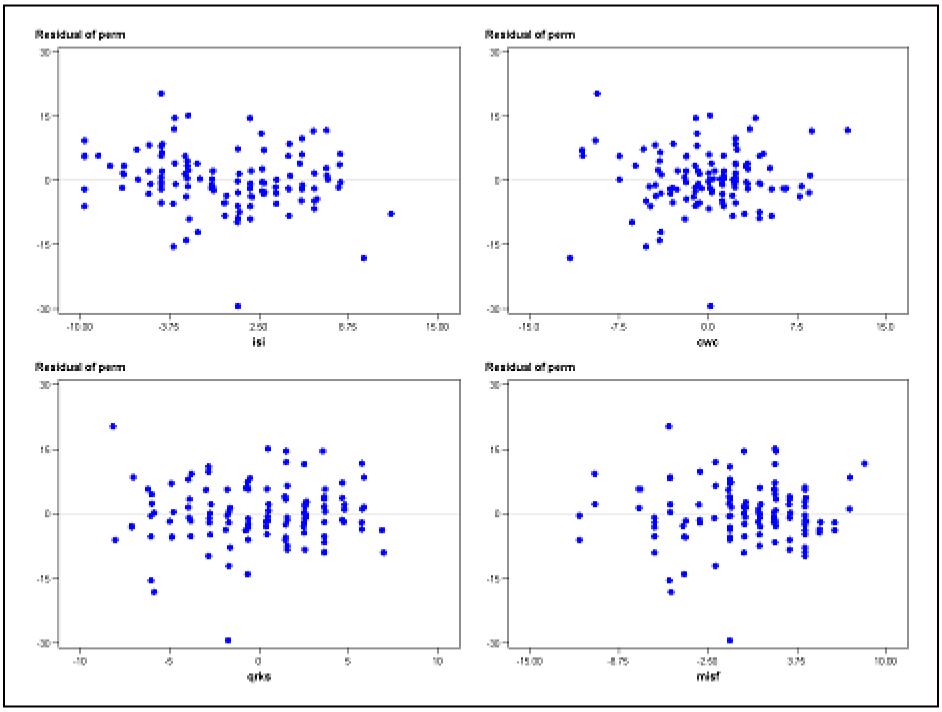
Additionally, the theory-driven statistics test indicates that the Kolmogorov-Smirnov test (Table 5-12) confirms the previous conclusion.

Tests for Normality-Residuals QRC					
Test	Statistic		p Value		Ho Normality
Kolmogorov-Smirnov	D	0.07694	Pr > D	0.0786	Not rejected at 5%

Table 5-12 Normality test for residuals QRC model

PERM Model Residuals Normality Analysis

Regarding the analysis of normality of the residuals of the PERM model there are some points to note: as in the previous analysis of the QRC residuals, there is no evidence of patterns that affect the model assumptions The residuals (Figure 5.10) appear equally distributed on each side of the mean for all variables only with some point dispersion in the perceived quality of communication but with balanced concentration around the residual mean.



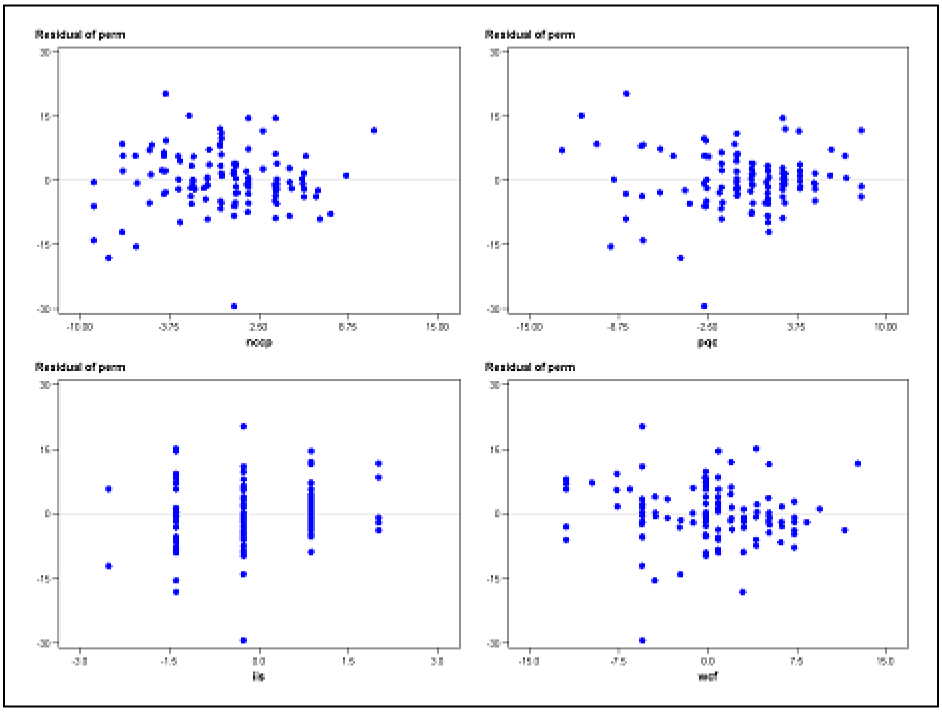


Figure 5-8 Residuals observations of the regression on the PERM Model

The review of the distribution of the PERM residuals shows, in the histogram and in the Q-Q and probability plots, a point that is an outlier. The review of the original data showed that effectively this point corresponds to a record that is an outlier. This outlier appears because the answer of the items in perm question were only the value 1 for all the items whereas no answer in these items were a combination of values above 2, mainly 3 and up, in the Likert scale. Without removing the outlier the PERM residuals tests of normality are not passed (Table 5-13).

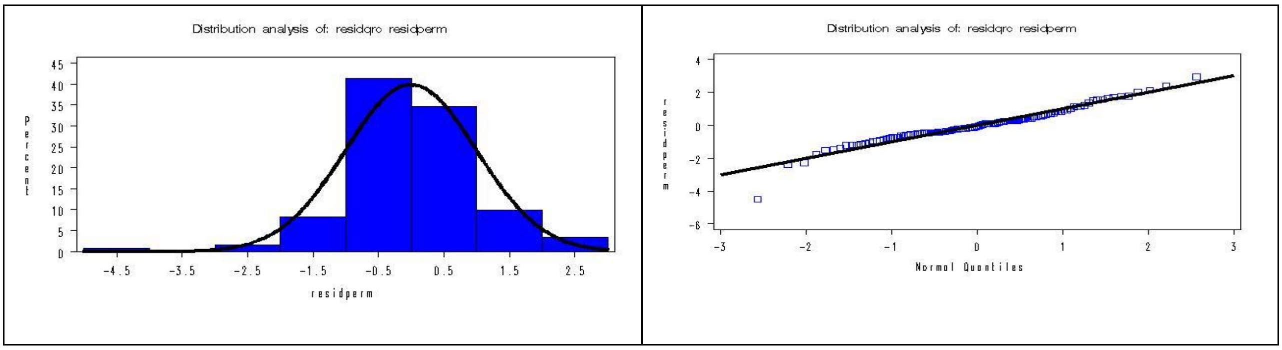


Figure 5-9 Graphic Normality tests for residuals of PERM Model, Histogram and QQ-Plot Normality

Test of for Normality-Residuals Perm			
Test	D	p-value	Ho Normality
Kolmogorov-Smirnov	0.0826	0.042	Not supported at 5%

Table 5-13 Test normality of residuals PERM model before the outlier was removed

However, removing the outlier of the PERM residuals a good fit to the normal distribution is found (Figures 5-11 and 5-12). The number of values out of the interval -2 to 2 is less than 5% (5 points of 120). Additionally, the Kolmogorov-Smirnov test indicates that null hypothesis cannot be rejected (Table 5-14) at 5%. Thus, given the Figure 5-10, 95% of the points in the range of -2 to 2, the histogram, the Q-Q and probability plot and the Kolmogorov-Smirnov test, the normality hypothesis for the PERM residuals can be accepted.

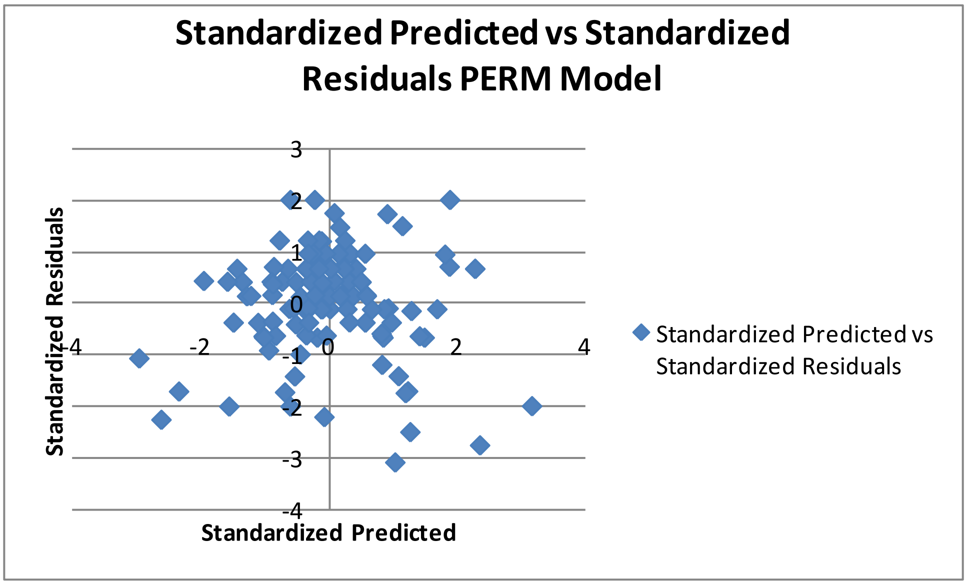


Figure 5-10 PERM Model residuals standardized vs. predicted

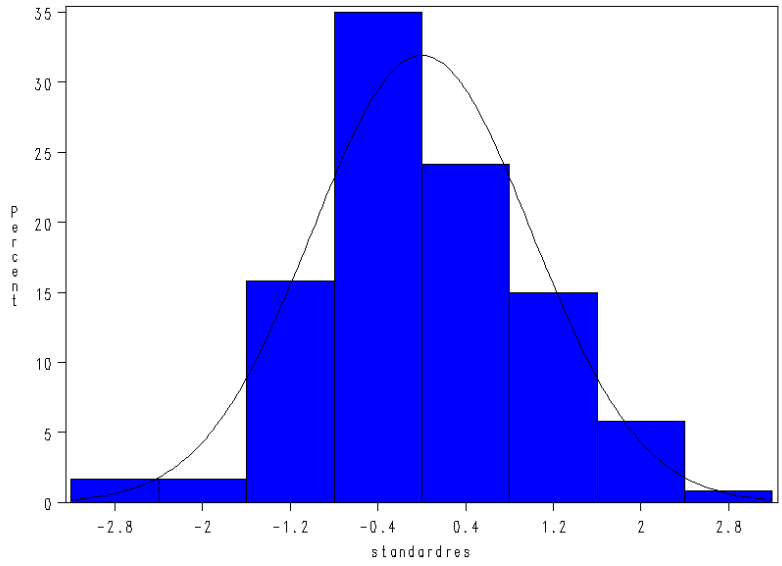


Figure 5-11 Histogram and Distribution for PERM model after the outlier was removed

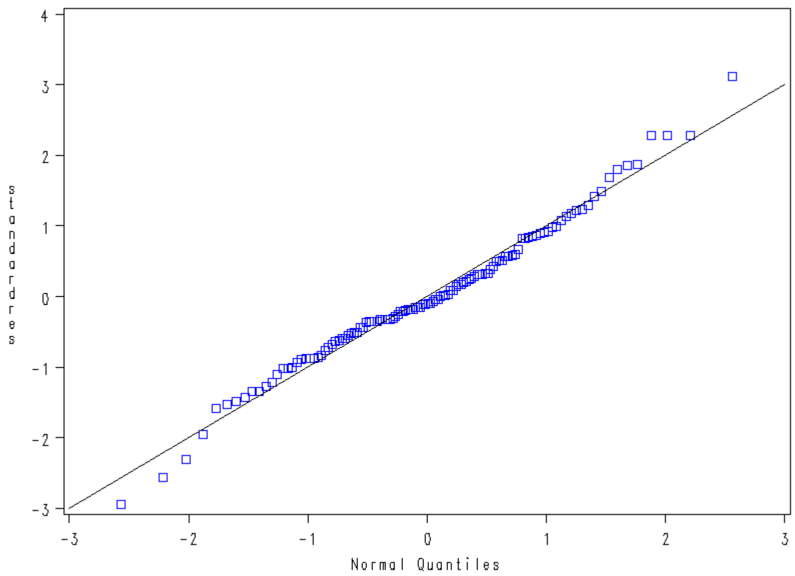


Figure 5-12 Q-Q Plot for the PERM model after the outlier was removed

Tests for Normality for Perm Model 120 sample points				
Test	**Statistic**		**p Value**	
Kolmogorov-Smirnov	**D**	0.068666	**Pr > D**	>0.1500

Table 5-14 Formal test of normality PERM model after the outlier was removed

5.2.1.5. No multicollinearity

Tables 5-7 and 5-8 indicate that none of the correlations is above the threshold of 0.7. Tables 5-15 and 5-16 present the Tolerance as well that is the reciprocal of Variance Inflation factor (1/Variance Inflation factor). This means that with values close to 1 in the variance inflation factor, small inter-correlations among independent variables are indicated. On the other hand, the Variance Inflation factor in none of the models presents values greater than 10 (SAS Reference 9.1.3) to indicate collinearity.

Additionally, the condition index (Table 5-17) indicates the degree of collinearity, for the model QRC. According to Table 5-17 none of the condition indices has a value over 30 and then there is no evidence of mutlicollinearity.

Dependent Variable QRC Parameter Estimates								
Variable	**Label**	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**	**Tolerance**	**Variance Inflation**
Intercept	Intercept	**1**	0.000	0.235	0.000	1.000	.	0.000
isi	isi	**1**	0.085	0.060	1.410	0.161	0.664	1.506
cwc	cwc	**1**	0.142	0.092	1.540	0.126	0.368	2.716
qrks	qrks	**1**	0.266	0.098	2.730	0.007	0.434	2.307
misf	misf	**1**	0.163	0.087	1.880	0.063	0.433	2.308
nccp	nccp	**1**	-0.047	0.093	-0.500	0.615	0.404	2.475
pqc	pqc	**1**	0.191	0.080	2.400	0.018	0.516	1.936
iis	iis	**1**	0.127	0.298	0.430	0.672	0.628	1.592
wcf	wcf	**1**	0.157	0.065	2.400	0.018	0.512	1.951

Table 5-15 Test for collinearity QRC Model

Dependent Variable PERM Parameter Estimates								
Variable	**Label**	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**	**Tolerance**	**Variance Inflation**
Intercept	Intercept	**1**	0.000	0.622	0.000	1.000	.	0.000
isi	isi	**1**	-0.287	0.159	-1.810	0.073	0.664	1.506
cwc	cwc	**1**	0.206	0.244	0.840	0.401	0.368	2.716
qrks	qrks	**1**	0.017	0.258	0.070	0.948	0.434	2.307
misf	misf	**1**	0.115	0.230	0.500	0.617	0.433	2.308
nccp	nccp	**1**	-0.017	0.247	-0.070	0.944	0.404	2.475
pqc	pqc	**1**	0.289	0.211	1.370	0.173	0.516	1.936
iis	iis	**1**	1.072	0.788	1.360	0.177	0.628	1.592
wcf	wcf	**1**	-0.088	0.173	-0.510	0.614	0.512	1.951

Table 5-16 Test for collinearity PERM Model

The proportion of the variation and the eigenvalues calculation uses the same variance-covariance matrix for the models QRC and PERM and the summary (Table 5-17) is the same. This means that the conclusion for the QRC model is applicable to the PERM model. No multicollinearity is observed.

Dependent Variable QRC Collinearity Diagnostics												
Number	**Eigenvalue**	**Condition Index**	**Proportion of Variation**									
			Intercept	**isi**	**cwc**	**qrks**	**misf**	**nccp**	**pqc**	**iis**	**wcf**	
1	4.302	1.000	0.000	0.010	0.014	0.015	0.015	0.015	0.013	0.014	0.014	
2	1.173	1.915	0.000	0.232	0.002	0.015	0.007	0.001	0.087	0.081	0.076	
3	1.000	2.074	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
4	0.605	2.666	0.000	0.122	0.027	0.141	0.000	0.024	0.000	0.634	0.000	
5	0.531	2.846	0.000	0.062	0.067	0.034	0.373	0.008	0.252	0.038	0.051	
6	0.433	3.153	0.000	0.457	0.014	0.066	0.032	0.025	0.009	0.000	0.655	
7	0.396	3.297	0.000	0.109	0.128	0.207	0.047	0.418	0.182	0.025	0.002	
8	0.327	3.629	0.000	0.008	0.230	0.190	0.086	0.258	0.431	0.132	0.054	
9	0.234	4.287	0.000	0.000	0.517	0.334	0.440	0.252	0.026	0.077	0.148	

Table 5-17 Eigenvalues for QRC Model and PERM Models

In summary, neither in the case for perceived quality of risk control nor in the perceived value of ERM do the models indicate multicollinearity.

5.2.1.6. No outlier distortion

There is not an evident outlier in the set of residuals for QRC but there is an outlier point for the PERM model. The outlier identification used the plots indicated before (Section 5.2.1.4). The outlier was removed for the subsequent PERM analysis.

5.3. QRC Model Results

There are two models in the following sections: one is the general multiple regression model and the other the stepwise regression model.

5.3.1. General Multiple Regression Results for QRC Model

The analysis uses perceived quality of risk control as the dependent variable. The independent variables used are those indicated in section 4.4. The results are shown in Table 5-18 with an R-squared of 0.6097, and a power value of 1, which indicates the existence of relationships between the dependent variable and the significant variables (Mendenhall 1971).

The multiple regression model shows that the variables perceived quality of risk knowledge sharing, perceived quality of communication among people and web channel functionality are significant at alpha of 5%. Thus there is one variable with a significant influence on the perceived quality of risk control from each of the people, process and technology categories.The highest contribution to the dependent variable is from the perceived quality of risk knowledge sharing. The *nccp;* even though it is not significant, indicates a negative relationship to *qrc* as the negative parameter estimation shows.

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	8	1171.502	146.4378	21.87	<.0001
Error	112	749.8018	6.69466		
Corrected Total	120	1921.304			
Root MSE	2.5874	R-Square	0.6097		
Dependent Mean	-4.77E-16	Adj R-Sq	0.5819		
Coeff Var	-5.42E+17				

Parameter Estimates						
Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	Intercept	1	-9.89E-16	0.23522	0	1
isi	isi	1	0.0845	0.05991	1.41	0.1612
cwc	cwc	1	0.14187	0.0921	1.54	0.1263
qrks	qrks	1	0.26616	0.09763	2.73	0.0074
misf	misf	1	0.16348	0.08694	1.88	0.0627
nccp	nccp	1	-0.04713	0.09334	-0.5	0.6146
pqc	pqc	1	0.19133	0.07959	2.4	0.0179
iis	iis	1	0.12673	0.29802	0.43	0.6715
wcf	wcf	1	0.15733	0.06548	2.4	0.0179

Table 5-18 Results of multiple regression model for the dependent variable QRC perceived quality of risk control

The people variables *cwc* and *iis*, do not appear significant in the model leaving only *pqc* as a significant variable influencing positively the *qrc* variable. A model with interactions (Table 9-7) was performed and observed the significant level of the squared terms and those with second degree interaction, in general they appeared non-significant except some of them that had negative coefficients with no clear interpretation.

5.3.2. Stepwise Regression for QRC and the whole sample

The application of the stepwise model brought into the model the variables: the perceived quality of risk knowledge sharing, web channel functionality, perceived quality of risk communication among people, and risk management information system functionality. The first variable enter in the model was perceived quality of risk knowledge sharing followed by web channel functionality, perceived quality of communication among people. and risk management information system functionality. The other four variables were not significant at an alpha of 5%.

The final stepwise regression model has R-squared of 0.5916 and a power of 1, indicating a proper fit of the model and the existence of the relationships between dependent variable and independent variables. These results show that two technology variables are included in the model; the process variable and one people variable (Table 5-19).

Stepwise Selection: Step 1
Variable qrks Entered: R-Square = 0.4177 and C(p) = 50.1031

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	802.6062	802.60616	85.38	<.0001
Error	119	1118.698	9.40082		
Corrected Total	120	1921.304			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	-4.20E-16	0.27873	2.14E-29	0	1
qrks	0.70383	0.07617	802.60616	85.38	<.0001

Stepwise Selection: Step 2
Variable wcf Entered: R-Square = 0.5363 and C(p) = 18.0816

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	1030.368	515.18419	68.23	<.0001
Error	118	890.9358	7.5503		
Corrected Total	120	1921.304			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	-1.10E-15	0.2498	1.45E-28	0	1
qrks	0.53864	0.0746	393.65442	52.14	<.0001
wcf	0.29875	0.05439	227.76222	30.17	<.0001

Stepwise Selection: Step 3
Variable pqc Entered: R-Square = 0.5724 and C(p) = 9.7210

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	1099.729	366.57628	52.2	<.0001
Error	117	821.5754	7.02201		
Corrected Total	120	1921.304			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	-1.16E-15	0.2409	1.64E-28	0	1
qrks	0.40652	0.08332	167.14734	23.8	<.0001
pqc	0.22592	0.07188	69.36046	9.88	0.0021
wcf	0.27642	0.05293	191.48362	27.27	<.0001

Stepwise Selection: Step 4
Variable misf Entered: R-Square = 0.5916 and C(p) = 6.2135

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	1136.6	284.14991	42	<.0001
Error	116	784.7045	6.76469		
Corrected Total	120	1921.304			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	-1.34E-15	0.23645	2.18E-28	0	1
qrks	0.31323	0.09102	80.11152	11.84	0.0008
misf	0.18689	0.08005	36.87081	5.45	0.0213
pqc	0.22441	0.07056	68.42698	10.12	0.0019
wcf	0.21834	0.05761	97.1789	14.37	0.0002

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Label	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	qrks		qrks	1	0.4177	0.4177	50.1031	85.38	<.0001
2	wcf		wcf	2	0.1185	0.5363	18.0816	30.17	<.0001
3	pqc		pqc	3	0.0361	0.5724	9.721	9.88	0.0021
4	misf		misf	4	0.0192	0.5916	6.2135	5.45	0.0213

Table 5-19 Results Stepwise regression for QRC Perceived Quality risk control

These regression results are aligned with the one presented for the individual correlations indicating that the perceived quality of risk knowledge sharing is most significant, either one by one or taking all variables at the same time. However, when all the variables are acting together the technology variables *isi* and *nccp*.do not appear significant.

The next section refers to the analysis of the demographic groups. Stepwise regressions were performed for all demographic groups including the power analysis of the model to validate results. The analysis of the significant variables in the models identifies whether or not any hypothesis was supported in any of the groups..

5.3.3. Stepwise Regression QRC Model using demographic information

The influence of the sample size, the number of the independent variables and the value of R-squared for the models in each demographic group require the use of the power concept to assess the models' capacity to identify the relationships among the variables.

The power value (See Section 4.6) was calculated for all models and is summarized in the following tables according to each group.

Summary Stepwise Regression by demographic groups						
Group	Category	Dependent Variable	Number of observations	Model R squared	Significant variables	Power
Risk Management work Area	Market risk	qrc	37	0.52	cwc,misf	0.99
	Operational risk	qrc	11	0.73	qrks	0.22
	Credit risk	qrc	47	0.75	wcf,qrks,isi	1
	Currency risk	qrc	1	-	-	N/A
	Legal/regulatory risk	qrc	3	-	-	N/A
	Capital risk	qrc	6	0.81	wcf	1
	Other	qrc	16	0.72	pqc	0.83

Table 5-20 Stepwise regression results using demographic information-Risk Management work area (The N/A in the power column means no significant value)

There are four models with suitable power (Table 5-20) and significant results, for the credit risk, market risk, capital risk and "other" groups. Interestingly, the significant variables were rather different from the overall model, with perceived value of information systems integration appearing in the model for the credit risk group, organisational capacity for work coordination being the most significant variable for the market risk group, and perceived quality of communication among people being the only significant variable for the “other” group.

Summary Stepwise Regression by demographic groups						
Group	Category	Dependent Variable	Number of observations	Model R squared	Significant variables	Power
Risk Management process	Risk identification	qrc	17	0.57	cwc,misf	0.59
	Risk hedging	qrc	2	-	-	N/A
	Risk transfer	qrc	1	-	-	N/A
	Risk quantification	qrc	47	0.43	qrks,misf	0.99
	Risk classification	qrc	3	-	-	N/A
	Risk evaluation	qrc	29	0.88	cwc,misf,nccp,pqc	1
	Risk mitigation	qrc	12	0.4	pqc	0.14
	Risk mapping	qrc	3	-	-	N/A
	Other	qrc	7	0.94	qrks	N/A

Table 5-21 Stepwise regression results using demographic information-Risk Management process (The N/A in the power column means no significant value)

There are two models involving the risk management process (See Table 5-21) with good R-squared and a suitable power value groups: risk quantification and risk evaluation. In the first case, the quality of risk knowledge sharing and the risk management information systems functionality appear as the significant variables to describe the quality of risk control. For the risk evaluation model the significant variables again include the functionality of the risk management information system. Three additional variables appear in the risk evaluation model: capacity for work coordination, perceived quality of communication and the network capacity for connecting people.

Summary Stepwise Regression by demographic groups						
Group	Category	Dependent Variable	Number of observations	Model R squared	Significant variables	Power
Years in the position	Less than 1 year	qrc	16	0.67	qrks	0.72
	1 to less than 3 years	qrc	49	0.52	qrks,iis	0.99
	3 to less than 5 years	qrc	30	0.56	qrks,cwc	0.98
	5 to less than 10 years	qrc	19	0.66	wcf,misf	0.89
	More than 10 years	qrc	7	0.96	isi,cwc	N/A

Table 5-22 Stepwise regression results using demographic information-Risk Management years in the position (The N/A in the power column means no significant value)

The models for the time in the RM position categories (See Table 5-22) all have a power greater than 0.7 and an R-squared higher than 0.5, which means they are valid models to use, except for the group that represents more than 10 years in the RM position. The results show that perceived quality of risk knowledge sharing is significant for the groups with up to five years in the RM position. The significant variables for the 1 to 3 years group included the people's interaction for risk management information system design, and for the 3 to 5 years group included the organisational capacity for work coordination. The group of more than 5 and less than 10 years in the RM position did not include perceived quality of risk knowledge sharing; the significant variables that appeared were web channel functionality and risk management information systems functionality.

Summary Stepwise Regression by demographic groups						
Group	Category	Dependent Variable	Number of observations	Model R squared	Significant variables	Power
Years of experience risk management	Less than 1 year	qrc	4	0.94	pqc	N/A
	1 to less than 3 years	qrc	15	0.43	misf	0.26
	3 to less than 5 years	qrc	26	0.77	qrks,pqc,wcf	0.99
	5 to less than 10 years	qrc	43	0.39	cwc,misf	0.94
	More than 10 years	qrc	33	0.75	cwc,qrks,wcf	1

Table 5-23 Stepwise regression results using demographic information-Risk Management years of experience risk management (The N/A in the power column means no significant value)

Table 5-23 shows that according to the risk management experience there are three models with sufficient power for the groups. One of these is the group with more than 3 years of experience. The model for this group includes as significant variables, perceived quality of risk knowledge sharing, perceived quality of communication among people, web channel functionality, organisational capacity for work coordination and risk management information system functionality. The groups with experience between 3 and 5 years and more than 10 years share in common the variables perceived quality of risk knowledge sharing and web channel functionality. The perceived quality of communication among people appears only for the group model with 3 to 5 years of experience, and risk management information systems functionality only for the model of the group with more than 5 years and less than 10 years of RM experience. The models for the group with more experience, which is more than 10 years, include the organisational capacity for work coordination, perceived quality of risk knowledge sharing and web channel functionality as significant variables.

In general the group models for the quality of risk control show that in different groups the KM variables can be significant, and those with the best R-squared and better power value included perceived quality of risk knowledge sharing, web channel functionality, organisational capacity for work coordination and risk management information system functionality. However, the variable perceived value of information systems integration does not appear in any group that has a power value more than 80%. The quality of network capacity for connecting people appeared only for the group of risk evaluation, and the variable people's interaction in the information system design appeared only for the group with 1 to 3 years in the RM position.

Therefore, the hypothesis tests are summarized (Table 5-24) as not all the hypotheses are supported. From the people variables group only H2a is supported overall, which means there is a positive association of perceived quality of communication among people with perceived quality of risk control. The process variable perceived quality of risk knowledge sharing is overall positively associated with perceived quality of risk control, supporting the hypothesis H4a and from the group of technology variables the risk management information system functionality and the web channel functionality are positively associated with the perceived quality of risk control, supporting the hypotheses H5a and H6a overall. The conclusion of the test is mainly based on the stepwise regression model that includes the fact of the co-existence of the variables in the risk management organisation and from the statistical point of view selects only the variables that contribute significantly to the dependent variable perceived quality of risk control.

From the analysis of the demographic groups the organisational capacity for work coordination is significant for: Market Risk group, Risk Identification, Risk Evaluation, 3 to 5 years in RM position, and for the groups with more than 5 year of RM experience. This means that the hypothesis H1a is supported for these groups but not in general. The same happens with the variables *iis*, *isi*, *nccp* that the hypotheses are valid only in some groups but not in general. Hypothesis H3a is only supported for the group of 1 to 3 years of RM position; hypothesis H7a is only supported by the credit risk group and the hypothesis H8a is only supported for the risk evaluation group.

Hypotheses	Results
People	
H1a: Organisational capacity for work coordination (*cwc*) is positively associated with the perceived quality of risk control(*qrc*)	Not Supported Overall Supported for the following groups: • Market Risk In Risk Management Work Area • Risk evaluation Risk Management Process • 3 to less than 5 years in the position • 5 years or more of Risk Management Experience
H2a: The perceived quality of communication among people (*pqc*) is positively associated with perceived quality of risk control(*qrc*)	Supported
H3a: Perceived quality of people interactions in the ERMIS design (*iis*) is positively associated with the perceived quality of risk control(*qrc*)	Not Supported Overall Supported for the following group: 1 to less than 3 years in the position
Process	
H4a: The perceived quality of risk knowledge sharing (*qrks*)is positively associated with the perceived quality of risk control(*qrc*)	Supported
Technology	
H5a: The risk management information system functionality (*misf*) is positively associated with the perceived quality of risk control(*qrc*)	Supported
H6a: The web channel functionality (*wcf*) is positively associated with the perceived quality of risk control(*qrc*)	Supported
H7a: The perceived integration of the information systems (*isi*) is positively associated with the perceived quality of risk control(*qrc*)	Not Supported Overall Supported for the following group: Work area: Credit risk
H8a: The quality of the network capacity for connecting people (*nccp*) is positively associated with the perceived quality of risk control(*qrc*)	Not Supported Overall Supported for the following group: RM Process: Risk evaluation

Table 5-24 Summary hypotheses test risk control

5.4. PERM Model Results

The following sections review the PERM models: general multiple regression and stepwise regression:

5.4.1. General Multiple Regression Results for PERM Model

The model for *perm* variable was analysed with 120 sample points, the outlier was removed. The KM variables' relationship to the perceived value of ERM implementation as dependent variable was analysed using multiple regression. The results of the multiple regression (Table 5-25) show that the R-squared is 0.17 and the power 0.95; however, no variable can be identified with a significant relationship to *perm* at the 5% level of significance. A noteworthy point is that three variables suggest an inverse relationship to the perceived value of ERM implementation; these are: *isi*, *qrks*, and *wcf*.

Analysis of Variance					
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	8	883.615	110.452	2.840	0.007
Error	111	4322.983	38.946		
Corrected Total	119	5206.599			
Root MSE	6.241	**R-Square**	0.170		
Dependent Mean	0.257	**Adj R-Sq**	0.110		
Coeff Var	2429.768				

Parameter Estimates						
Variable	**Label**	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	Intercept	**1**	0.257	0.570	0.450	0.653
isi	isi	**1**	-0.246	0.145	-1.700	0.092
cwc	cwc	**1**	0.278	0.223	1.250	0.214
qrks	qrks	**1**	-0.038	0.236	-0.160	0.872
misf	misf	**1**	0.133	0.210	0.630	0.529
nccp	nccp	**1**	0.046	0.226	0.200	0.838
pqc	pqc	**1**	0.240	0.192	1.250	0.215
iis	iis	**1**	1.035	0.719	1.440	0.153
wcf	wcf	**1**	-0.201	0.160	-1.260	0.210

Table 5-25 PERM multiple regression model results, outlier removed

5.4.2. Stepwise Regression for PERM

A stepwise regression was carried out, using the *perm* dependent variable and all the eight independent variables with 120 sample points after the outlier was removed. Again using an alpha of 5%, the only variable that entered and continued in the model was the perceived quality of risk communication among groups and no other variables were significant (Table 5-26).

The model has a low R-squared value of 0.09; however, the value of R-squared is an indicator that can be used for the assessment of the regression model even though the low value may not be a good indicator for prediction. In some of the social sciences the R-squared values are acceptable and provide understanding of the relationships. Therefore, the results of stepwise regression indicate the existence of a relationship between the perceived quality of communication among people and the perceived value of ERM implementation. (Rosenthal and Rubin, 1982; Aczel, 1993; Howell, 1997; Newman and Newman, 2000; Colton and Bower, 2002)

With respect to the previous point Golderberger (1978) pointed out: “From our perspective, R^2 has a very modest role in regression analysis … nothing in CR (Classical regression model) requires that R^2 be high. Hence a high R^2 is not evidence in favour of the model and a low R^2 is not evidence against it. In fact the most important thing about R^2 is that it is not important in the CR model. The CR model is concerned with parameters in a population. Not with goodness of fit in the sample…” Given the low R-squared value the power of the model was evaluated and the value of 0.65 was found which is smaller than the threshold of 0.8 used. Therefore, the model capacity to describe the relationships of the variables is not adequate.

Root MSE	6.3355	**R-Square**	0.0903
Dependent Mean	0.2568	**Adj R-Sq**	0.0826
Coeff Var	2466.7		

Analysis of Variance					
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	1	470.3054	470.31	11.72	0.0009
Error	118	4736.293	40.138		
Corrected Total	119	5206.599			

Parameter Estimates						
Variable	**Label**	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	Intercept	**1**	0.24575	0.57835	0.42	0.6717
pqc	pqc	**1**	0.48032	0.14032	3.42	0.0009

Table 5-26 PERM Stepwise regression model results

5.4.3. Stepwise Regression for PERM Model Using Demographic Information

The demographic information for the PERM model was used and the summary of the models in the stepwise model is presented in the following tables. The tables indicate the R-squared value and power calculation.

Summary Stepwise Regression by demographic groups						
Group	Category	Dependent Variable	Number of observations	Model R squared	Significant variables	Power
Years of experience risk management	Less than 1 year	perm	4	no model		
	1 to less than 3 years	perm	15	0.46	pqc	0.28
	3 to less than 5 years	perm	26	0.18	iis	0.23
	5 to less than 10 years	perm	43	0.10	iis	0.23
	More than 10 years	perm	32	0.13	pqc	0.21

Table 5-27 Stepwise regression results using demographic information-Risk Management years of experience risk management (The N/A in the power column means no significant value)

The following tables (Table 5-27, 5-28, 5-29, 5-30) indicate that none of the models have enough power to consider them suitable for hypothesis test; even though in some cases some of the variables appear significant in the model.

Summary Stepwise Regression by demographic groups						
Group	Category	Dependent Variable	Number of observations	Model R squared	Significant variables	Power
Years in the position	Less than 1 year	perm	16	0.55	qrks	0.48
	1 to less than 3 years	perm	49	no model	no variable	N/A
	3 to less than 5 years	perm	29	0.33	pqc	0.58
	5 to less than 10 years	perm	19	no model	no variable	N/A
	More than 10 years	perm	7	0.71	pqc	N/A

Table 5-28 Stepwise regression results using demographic information-Risk Management years in the position (The N/A in the power column means no significant value)

Summary Stepwise Regression by demographic groups						
Group	Category	Dependent Variable	Number of observations	Model R squared	Significant variables	Power
Risk Management process	Risk identification	perm	16	no model	no variable	N/A
	Risk hedging	perm	2	no model	no variable	N/A
	Risk transfer	perm	1	no model	no variable	N/A
	Risk quantification	perm	47	0.24	isi,iis	0.69
	Risk classification	perm	3	no model	no variable	N/A
	Risk evaluation	perm	29	0.36	pqc	0.65
	Risk mitigation	perm	12	no model	no variable	N/A
	Risk mapping	perm	3	no model	no variable	N/A
	Other	perm	7	no model	no variable	N/A

Table 5-29 Stepwise regression results using demographic information-Risk Management process (The N/A in the power column means no significant value)

Summary Stepwise Regression by demographic groups						
Group	Category	Dependent Variable	Number of observations	Model R squared	Significant variables	Power
Risk Management work Area	Market risk	perm	37	no model	no variable	N/A
	Operational risk	perm	10	no model	no variable	N/A
	Credit risk	perm	47	0.2	pqc	0.65
	Currency risk	perm	1	no model	no variable	N/A
	Legal/regulatory risk	perm	3	no model	no variable	N/A
	Capital risk	perm	6	0.91	iis	N/A
	Other	perm	16	no model	no variable	N/A

Table 5-30 Stepwise regression results using demographic information-Risk Management area (The N/A in the power column means no significant value)

Thus the summary at alpha = 0.05, (Table 31) none of the hypotheses can be supported because there is enough power in the models to consider them suitable.

Hypotheses	Results
People	
H1b: Organisational capacity for work coordination (*cwc*) is positively associated with the perceived value of the ERM implementation (*perm*)	Not Supported
H2b: The perceived quality of communication among people (*pqc*) is positively associated with perceived value of the ERM implementation (*perm*)	Not Supported
H3b: Perceived quality of people interactions in the ERMIS design (*iis*) is positively associated with the perceived value of the ERM implementation (*perm*)	Not Supported
Process	
H4b: The perceived quality of risk knowledge sharing (*qrks*) is positively associated with the perceived value of the ERM implementation (*perm*)	Not Supported
Technology	
H5b: The risk management information system functionality (*misf*) is positively associated with the perceived value of ERM implementation (*perm*)	Not Supported
H6b: The web channel functionality (*wcf*) is positively associated with the perceived value of ERM implementation (*perm*)	Not supported
H7b: The perceived integration of the information systems (*isi*) is positively associated with the perceived value of the ERM implementation (*perm*)	Not Supported
H8b: The quality of the network capacity for connecting people (*nccp*) is positively associated with the perceived value of the ERM implementation (*perm*)	Not Supported

Table 5-31 Summary of the hypotheses test for the PERM dependent variable

The final results are in Table 5-32, including only the models with significant variables and sufficient power. None of the *perm* models meet these criteria; the best ones for the whole sample and by groups do not have power values above the threshold (0.8), indicating no support to any of the hypotheses:

Stepwise Model	Group	Significant Variables	R-Squared	Power
QRC	Whole sample	qrks, wcf,pqc,misf	0.5916	1.000
QRC	Credit Risk	wcf, qrks,isi	0.75	1
QRC	Risk Quantification	qrks, misf	0.43	0.99
QRC	Risk Evaluation	cwc, misf,nccp,pqc	0.88	1
QRC	5 to 10 years position	wcf, misf	0.66	0.89
QRC	RM experience 3 to 5 years	qrks,pqc,wcf	0.77	0.99

Table 5-32 Summary of model findings

5.5. Summary

In this chapter the results of the models were presented. The process followed for the data analysis was concentrated on the review of the assumptions of the models that were performed, the validation of these assumptions and to obtain the model results. The models used were univariate and bivariate through exploratory data analysis mainly though correlation analysis, and multivariate analysis through Anova, general multiple regression and stepwise regression.

Each dependent variable was described by a multiple regression and stepwise regression. The dependent variable perceived quality of risk control was associated with the KM variables perceived quality of risk communication, perceived quality of risk knowledge sharing, risk management information system functionality and web channel functionality. For the dependent variable perceived value of ERM implementation only the variable perceived quality of risk communication appeared associated but the models are not robust enough to support the hypotheses.

In order to make the decision for the hypothesis testing a power analysis was used and the analysis performed by demographic groups. The reason for using the power analysis was to validate if the model had a good fit or not.

In the next chapter the discussion and analysis of the results show their interpretation using the perspective of people, processes and technology.

6. Chapter Six Discussion and Implications

The aim of this research was to discover relationships between KM variables and two risk management concepts: perceived quality of risk control and perceived value of ERM implementation, in order to identify the contribution of KM to RM practice. The survey data were analysed using multiple and stepwise regression. Significant associations were found between the KM variables and perceived quality of risk control (see Table 6-1), but none was found with the perceived value of ERM implementation.

Hypotheses QRC model	Results	Hypotheses PERM model	Results
People			
H1a: Organisational capacity for work coordination (*cwc*) is positively associated with the perceived quality of risk control(*qrc*)	Not Supported Overall Supported for the following groups: • Market Risk In Risk Management Work Area • Risk evaluation Risk Management Process • 3 to less than 5 years in the position • 5 years or more of Risk Management Experience	H1b: Organisational capacity for work coordination (*cwc*) is positively associated with the perceived value of the ERM implementation (*perm*)	Not Supported
H2a: The perceived quality of communication among people (*pqc*) is positively associated with perceived quality of risk control(*qrc*)	Supported	H2b: The perceived quality of communication among people (*pqc*) is positively associated with perceived value of the ERM implementation (*perm*)	Not Supported
H3a: Perceived quality of people interactions in the ERMIS design (*iis*) is positively associated with the perceived quality of the risk	Not Supported Overall Supported for the following group: 1 to less than 3 years in the position	H3b: Perceived quality of people interactions in the ERMIS design (*iis*) is positively associated with the perceived value of the ERM implementation (*perm*)	Not Supported
Process			
H4a: The perceived quality of risk knowledge sharing (*qrks* positively associated with the perceived quality of risk control(*qrc*)	Supported	H4b: The perceived quality of risk knowledge sharing (*qrks*) is positively associated with the perceived value of the ERM implementation (*perm*)	Not Supported
Technology			
H5a: The risk management information system functionality (*misf*) is positively associated with the perceived quality of risk control(*qrc*)	Supported	H5b: The risk management information system functionality (*misf*) is positively associated with the perceived value of ERM implementation (*perm*)	Not Supported
H6a: The web channel functionality (*wcf*) is positively associated with the perceived quality of risk control(*qrc*)	Supported	H6b: The web channel functionality (*wcf*) is positively associated with the perceived value of ERM implementation (*perm*)	Not supported
H7a: The perceived integration of the information systems (*isi*) is positively associated with the perceived quality of risk control(*qrc*)	Not Supported Overall Supported for the following group: Work area: Credit risk	H7b: The perceived integration of the information systems (*isi*) is positively associated with the perceived value of the ERM implementation (*perm*)	Not Supported
H8a: The quality of the network capacity for connecting people (*nccp*) is positively associated with the perceived quality of risk control(*qrc*)	Not Supported Overall Supported for the following group: RM Process: Risk evaluation	H8b: The quality of the network capacity for connecting people (*nccp*) is positively associated with the perceived value of the ERM implementation (*perm*)	Not Supported

Table 6-1 Summary QRC and PERM models and Hypotheses

In the following sections the discussion is focussed on the following two points: first, the meaning of the findings in the RM practice, model by model. This includes: understanding that KM can support the RM transformation based on the current RM circumstances, and the value added of the KM models to RM. Second, to review the possible bases of the ERKMAS design (KMS in the RM settings). All these points are under the umbrella of the organisation theory concepts (Section 2.1) that pointed out that the organisation design looks for knowledge moving from theory to practice and developing an environment of trust for knowledge exchange.

6.1. The meaning of the findings in RM practice

In Chapter 2 it was mentioned that a RM organisation involves people from multiple disciplines, different departments, various competences and with distinct kinds of problems and actions to perform, from complex quantitative modelling process up to developing reports and trading. The organisation can improve the practice on KM and it might be likely to have a positive effect on risk control, but will not have the same effect on the perceived value of ERM implementation. Additionally, the groups of the RM organisation tend to see KM influence on risk control and ERM in a different way. That is RM employees, according to experience, type of risk and risk process, observe the RM evolution differently; however, the quality of risk communication appears as a common denominator to improve risk control and ERM but with a different level of contribution. These observations are presented analyzing the models and hypotheses as follows:

6.1.1. Analysing the QRC model

Four KM variables were found to be significantly associated with the perceived quality of risk control: perceived quality of risk knowledge sharing (*qrks*), web channel functionality (*wcf*), perceived quality of communication among people (*pqc*) and the risk management information system functionality (*misf*). In particular the most influential variable for the perceived quality of risk control model is the perceived quality of risk knowledge sharing followed by the perceived quality of communication among people. This suggests that risk knowledge sharing and communication among people are social factors influencing risk control.

6.1.1.1. Process Hypothesis

The variable that has the highest influence in the perceived quality of risk control (QRC model) refers to the knowledge sharing process. This corresponds to the fourth hypothesis in the document: the perceived quality of risk knowledge sharing (*qrks*) is positively associated with the perceived quality of risk control (*qrc*) that was supported overall. This is a result that is aligned to the second hypothesis result: the perceived quality of communication among people is positively associated with the perceived quality of risk control. This indicates that in RM practice creating spaces for better communication among groups, improving messages, means of communication and a better risk knowledge sharing (*qrks*) contribute positively to the quality of risk control.

Knowledge sharing has barriers to overcome (Wang et al., 2006) such as: work environment, organisational trust to keep what O'Dell and Grayson (2003) indicate as the interest of people to learn, to share what they know and with this to achieve better results in particular in risk control. This result of the QRC model indicates that as Bosua and Scheepers (2007) explained, risk control is enriched by listening, asking, sharing ideas, giving advice and learning by observation. Equally, Dickinson (2001) expressed that knowledge is a factor to reduce risk; however, as Horton-Bentley (2006) said the diversity of activities by risk types affect risk control in case of reduced risk knowledge sharing.

Risk knowledge sharing is part of the activities that financial institutions need to deal with permanently. For instance, the support to consulting activities is crucial because financial institution customers are asking for answers about protection, investment or financial resources and the employees need to explain to people about options, conditions and possible outcomes. Moreover, King (2006a), Ipe(2003), Peterson (2006) and Pritchard (2001), as was presented in the framework of this research, identified that knowledge sharing produces dissemination, collaboration, innovation and acquisition of knowledge. However, there are issues to overcome and to take into consideration. For example, what is done in one area is input in another, and there are multiple stakeholders involved. This is in RM an area to work on, such as Beasley et al. (2009) pointed out: "However, only rarely do the individuals charged with risk management responsibilities come together to share risk oversight information."

To achieve the level needed for advising people requires training and sharing knowledge from people within the financial institutions. This action of sharing knowledge improves risk control from the customer's perspective. Similarly, the understanding and experience that employees have had with customers, markets, and economic sectors, are valuable for making proper decisions in different areas of the financial institution and supporting a better risk control. This means that the efforts in improving risk knowledge sharing are likely to have a positive impact in risk control practice.

Chapter 1 and sections 2.2.3 and 2.2.4 indicated some issues that financial institutions have had because of a silo culture and the lack of sharing the analysis of the impact on the organisation when new risks emerge for the organisations. New risks require new knowledge to be shared in order to improve risk control. This means that better risk knowledge sharing is likely to contribute to mitigate the issues of silo culture in RM. Additionally, Eppler (2008) pointed out that to communicate experience and errors from the perspective of the errors helps to overcome barriers in risk knowledge sharing or as Beasley and Frigo (2007) indicated, this is the opportunity for more people working together to improve RM practice.

6.1.1.2. People hypotheses

Regarding the people variables, three hypotheses were formulated. One was supported overall and the other two only for certain groups. The first hypothesis: the organisational capacity for work coordination (*cwc*) is positively associated with the perceived quality of risk control (*qrc*) is not supported overall, but it is supported by the market risk group in risk management work area groups; the same for the risk evaluation group in the risk management process groups, by the 3 to less than 5 years employees in the years in the position groups and the group with 5 years or more of risk management experience.

Coordination of actions was assumed important for improving risk control given the definition of organisations (Section 2.1) and the need for multiple RM groups working to support the organisation (Burton and Obel, 1995). The application of knowledge and the RM actions need the adaptation of the organisation in order to achieve the goal.

The first group to analyse is the market risk group. Results indicated that more risk control is likely to achieve when more work coordination is in place in an area such as market risk where people are involved in alignment of analysis, decisions and actions of trading and that need more knowledge of the roles and experience in RM. RM in market risk is a daily review of opportunities of investment and hedging which require need work coordination, more knowledge of the role and experience. These RM actions require people to review the risk involved, make decisions, and to call for action through selling or buying in a short period of time (Brown, 2001).

In the market risk group as Crouhy et al. (2001) said: "Risk integration offers all sorts of benefits. For example, financial institutions can combine the measurement of trading market risk and gap market risk to ensure that market risk is covered completely and consistently." This is an example of the coordination of actions and work to protect the organisation. Crouhy et al.(2001) continue saying " Best practice is also about the management of day-to-day risk communication. For example, risk management should discuss their risk analysis with senior trading management in a daily trading-room risk conference; the discussion should be prior to the opening of trading and might take around 30 minutes."

The difference with other groups, such as the credit risk one, is in the way as the decisions of credit risk work. With respect to credit risk depending on the amount; some risk indicators, some areas of analysis additional processes are required to be coordinated. For instance, when the credit transaction needs some endorsement or special conditions to mitigate risk there are various areas and processes involved. However, in the most of the cases risk control occurs more after the credit protocols are followed and the control is more on the conditions of the credit granting process.

The group of risk evaluation has a responsibility described by Crouhy et al. (2001) " The greater the market risk, the higher the rate of return that the bank can expect. The question is, how much risk exposure can the bank afford?" Answering the question using risk evaluation involves different areas and the views of the business areas. It requires work coordination. Risk evaluation supports trading market risk and trading credit risk (Crouhy et al., 2001).

The group with 3 to 5 years in the RM position is an example of the understanding of the role and the responsibilities, limitations and the need for learning experience in cases similar to risk management operations. The groups with more than 5 years are related to the practice in RM in the sense that more experience implies more responsibilities, defined in terms of amounts of exposure to manage, capacity to deal with special transactions and to support/reject and sign off (Decision authority) decisions in trading actions. These responsibilities imply more work coordination and involvement of more decision makers and steps.

Moreover, two concepts about organisations that identify why in some groups the work coordination is important for risk control are related to the maturity of the organisations as social collectives and knowledge systems (Alavi and Leidner, 2001) and as Nonaka and Takeuchi (1995) said: “The organisation is the vehicle for knowledge creation.”

The second hypothesis: the perceived quality of communication among people (*pqc*) is positively associated with perceived quality of risk control (*qrc*), is supported overall. In sections 2.2.2 and 2.2.3 was indicated that RM is a core competence in financial institutions and Dickinson (2001) pointed out that knowledge reduces risk. The support of this hypothesis indicates that good communication has positive effects on risk control and as Lam (2003) pointed out “ The risk management process does not stop at promoting awareness or measuring risk exposures.” There is a requirement to improve the messages and the means of communicating regarding the RM actions. Julibert (2008), Rollett (2003) and Waldvogel and Whelan (2008) indicate the value of access information with better communication, adding that without communication no KM is possible and that communication and good risk learning support collaboration.

In fact, in the context of day to day work of RM there are multiple things to communicate, from adverse events to people-related points, from market behaviour to new results of products and models that support these products. There is a large volume of information to process, which in many cases is not structured but is part of meetings, articles, and comments inside the business world. The RM actions require human contact or a means to communicate interpretation and views regarding potential issues or opportunities.

The third hypothesis: perceived quality of people interactions in the ERMIS design (*iis*) is positively associated with the perceived quality of risk control (*qrc*) is not supported overall but it is supported by the group with 1 to less than 3 years in the risk management position. This hypothesis referred to the value of designing, with the support of different people, a risk management system. The result indicates that the KM variable has no effect on the quality of risk control except for the group of RM employees that are relatively new in the position.

This result suggests that people, because of the independent study of risk in RM (Section 2.1), are concentrated on their own system applications. Tacit knowledge increases by interactions (Zack 1999b) and the value of interaction in the design of information systems (Clark et al. 2007) is clear in some RM groups because of the time and need for having more contact with other groups. The value of interacting with others in designing a common system with a wider participation of various areas is not on the mind of all RM members; even though, Crouhy et al.(2001) indicated that a best practice is " One firm, one view" and that " Risk management is only as strong as the weakest link." Or indicating that " Given the right environment and support, it is people who make everything happen."

6.1.1.3. Technology hypotheses

Regarding technology four hypotheses were formulated: two of these hypotheses were supported overall and two were supported by some of the groups. The results of the test of the technology hypotheses show that while the risk management information systems and the web channel functionalities are associated with the perceived quality of risk control, the integration of information systems and the network capacity for connecting people were not associated with *qrc* for the whole population, but only for some groups.

The hypothesis: the risk management information system functionality (*misf*) is positively associated with the perceived quality of risk control (*qrc*) is supported overall. Crouhy et al. (2001) presented as one of the most important points in RM the risk management system saying: " An effective risk management system needs to be able to generate the necessary risk management information on all risks, perform specific analytical functions, and permit multitasking." RM processes are based on data gathering, modelling and reporting (Section 2.2.6), all of them having various requirements of functionality in order to perform the RM actions. Risk control is the verification of the policies in practice and at the same time the answer to adverse events that can affect the organisation. Additionally, Caouette et al. (1998) expressed that the financial institution deal with information that is internal and external and internal and external users who demand features to add in the functionality of the system.

From the data perspective the functionality of the RMIS and the financial institutions need access to data from various sources and possibly a data architecture that is understood and managed from various areas, as Crouhy et al. (2001) identified the need of data marts, back up structures and very important particular points in market risk such as the distributed data bases with interconnected servers around the world..

From a reporting perspective the consistency and capacity to create different views is a way of controlling what is happening with the various risks to control. From the user's perspective, financial institutions need early warning systems, a means to qualify the risk levels and the scorecards of the portfolios. In general, the risk management information systems in RM consist of a group of system solutions according to products and transactions in treasury. All these needs in the RM activities and according to the results and as Smith and McKeen (2006) indicate the systems provide capacity to work with multiple groups and the capacity to maintain and improve other systems (Malhotra, 2003) in order to avoid what Rao and Marie (2007) identified as mis-management of risk .

Additionally, as support for the risk modelling analysis and work flow documents (Dinner and Kolber, 2005; Hormosi, 2004), all these elements and improvements are likely to have a positive effect on risk control. From the competitive advantage, Abrams et al. (2007) indicate the value of the improvement of the ERMIS:"This integration of reporting disciplines and overall risk management principles at the corporate level helps the business change from simple compliance to increased business efficiency."

Another hypothesis in the group of technology was: the web channel functionality (*wcf*) is positively associated with the perceived quality of risk control (*qrc*). The web channel functionality construct was built based on six items that referred explicitly to the risk management intranet. This hypothesis is supported overall. Myers (1996), indicated that knowledge enable actions and Jennex (2005 and 2006), Browman (2002), Carlsson (2003) Desouza and Awazu (2005) and Spies et al (2005) indicated that the intranet is a tool to use networks in daily work to integrate technical infrastructure in order to disseminate knowledge and to support KM processes. The intranet, in financial institutions, provides access to different components of the organisation's knowledge and in some cases, to operational tools. The RM intranet functionality enhancements according to the results, are likely to add value to risk control.

The intranet is a means for people-connectivity and the result suggests that people access to the intranet can be part of the work environment and that they perceive the intranet as a source and a means of accessing features that support their work; such as, risk information or work tools. Additionally, some of the behind the scene values of the intranet might be important for people to use: simplified language that is open to many different users, with a common and validated data meaning across the organisation.

The capabilities that financial institutions improve in the intranet are likely to have a positive effect on risk control. Zhang(2005) and Jennex (2006) expressed that the value of the web technologies is in integrating technical infrastructure and to improve the efficiency of KM (Shen and Tsai, 2008). Watson and Fenner (2000) pointed out the need to deal with various intranet projects and the capacity to work with different people (Holsaple and Jones, 2008) and to use the adequate features in the available technology (Watson and Fenner, 2000) in order to obtain an improved intranet for serving to risk control.

The next hypothesis in the group of technology was: the perceived integration of the information systems (*isi*) is positively associated with the perceived quality of risk control (*qrc*). This hypothesis was not supported overall and only supported by the credit risk group. Credit risk is the area that has been the core part of the operation of the financial institution from non-diversified financial institutions up to converting them into holding organisations (Section 2.1); various credit systems (Section 2..2.6) come from different business units and some are inheritance of strategic decisions; such as, mergers and acquisitions.

Additionally, credit risk manages some kind of data that comes from different sources: from transactions, customers, risk ratings, attributes of the products, attributes of the special conditions and so on. These data open up the variety of reports that are included in RM practice, such as: regions, exposure, risk levels, economic sectors, pricing, risk indicators etc. Credit risk is based more on the analysis of default probability than a customer could have. Concerning credit risk it is very important to analyse the customers quantitatively and qualitatively, which implies knowledge sharing about accounts and coordinating information in different formats, sources, etc.

Santomero (1996) points out some thoughts regarding credit risk that explain the difference from other risk areas: There is a standardized and accepted method to assess the quality of the loan. The reports are known and used by management. According to the reports the credits are monitored and reviewed periodically. In the case of market risk there are more components of the process to improve: ”Most banks have attempted to move beyond their gap methodology.” There are gaps in the duration analysis of the portfolio and the means for measuring and monitoring exposure.

In particular, the analysis suggests that the integration concept is not an important factor that produces a significant effect on the perceived quality of risk control. This no association of the integration systems with risk control suggests that in risk control the capability of having system tools working properly with the satisfaction of the users is more important than the integration of the systems.

On the other hand, what can affect the integration view is that some business areas are originally integrated in terms of the processes that they perform. This is the case of market risk where the software solutions and the operations are integral and the control of risk is in other areas, such as hedging and diversification. Meanwhile, for the credit risk group, the results show that better system integration can provide a better risk control.

Finally, the eighth hypothesis and the last of the technology group was: the quality of the network capacity for connecting people (*nccp*) is positively associated with the perceived quality of risk control (*qrc*). This hypothesis was not supported overall but it was supported by the group of people in risk evaluation. This result suggests that having a better structure to exchange data, conjoint work and collaborative work based on network capabilities, is more likely to contribute positively to risk control in the group of risk evaluation. In the RM organisation people working for the risk evaluation, need to deal with people from different areas in order to get the data and to provide their conclusions and recommendations. Risk evaluation includes the confirmation of the potential effects that the identified risk can have on the results as well as determines the risk management priorities.

In general in the other RM groups the models do not show a relationship between the network capacity to connect people and the perceived quality of risk control. The RM processes, centralized or not, are not applied to the same kinds of risk and the needs to deal with people in charge of the other parts of the RM processes probably requires more network support for risk evaluation (Crouhy, 2001) than the other processes that have independent activities and roles. Risk evaluation actions deal with different groups and multiple risks. Network capacity to connect people (*nccp*) in the RM context refers to portals, collaboration tools and virtual work capacity for performing the actions in RM. It also deals with discussing the results of the models, reviewing reports and their interpretation or sharing decisions using web-based tools. The results led to the conclusion that these kinds of tools are contributing to improving the risk control according to the risk evaluation group.

6.1.2. Analysing the PERM model

Though ERM is RM for the enterprise risk, the perceived value of ERM implementation, used in this research, appears weakly associated with the KM variable perceived quality of communication among people (*pqc*) and is not associated with the other KM variables used. The value of ERM implementation referred to collaboration, experience sharing, reuse of knowledge, quality of data, inter disciplinary and interdepartmental work, understanding of problems and solutions. This means that the efforts in improving KM are not perceived as having the same effect in implementing ERM as they have in controlling risk.

The distribution of answers according to the time in the position and risk management experience is a factor to take into consideration in the analysis of the PERM results. 94% of the answers came from people with less than ten years in the RM position and 73% were with less than ten years of experience. This combination of low time in a position and low experience for the most of the respondents indicates a potential lack of the holistic view of the RM function, because there is a reduced exposure to the whole map of the risk management work. Particularly, in a field where most of the roles are very specialized and reduced seniority potentially influences the access to more information and decisions.

Better communication among RM groups means better messages and communication tools among people working on various risks and various processes. This communication needs indicate a requirement for development of terms of reference, a common language, identification of bases of reporting that is understood across the organisation identifying variables and figures with appropriated labels. Better communication in RM means better meetings, for transactions definition, for planning and for making decisions based on the evidence presented by different risk management groups.

The results related to perception of the value of ERM in this research might be influenced by the grade of evolution of the organisation in the ERM field, the permeability of the ERM concepts, policies and messages into the organisation, the kind of respondents who are in the specialized RM positions; for example, the processes with people with more than 5 years of RM experience are: risk quantification (62%), risk evaluation (68%) and risk identification (64%) and that in terms of time in the RM position concentrated on the 1 and 5 years range: risk quantification(66%), risk evaluation (65%) and risk identification (82%).

Another valid discussion, regarding the results of the PERM model, related to the previous one is, the capacity to identify the strategic view versus the tactic view given the specialization of the work, Francis and Paladino (2008) pointed out that the best practices of ERM require a high grade of participation and involvement in strategic actions and formalization of the ERM actions in the regular course of business. The best practices of ERM include is an important investment in tools and infrastructure to increase transparency and to reach the daily analyst world. Franci and Palomine (2008) indicate:"ERM formal training is more rigorous at partner organisations, enabling the understanding of risk management at individual level." (Note that partner organisation refers to companies with innovative RM practices).

The evolution of RM to ERM is described by Bowling and Rieger (2005): "Recognize that ERM is not a quick process but a multiyear journey." The evolution according to these authors starts with compliance with the regulatory use of more standards for control supported by specific tasks; such as, mapping activities in order to reduce the silo and narrow view of departments, a level in risk management where organisations share a common language and where there is an audit effort based on risk, and finally, to get ERM. These authors conclude that, "Through increased communication, ERM leads to broader understanding and recognition of risks throughout the bank."

The RM evolution dynamics to ERM and people's perceptions of the process are factors to consider in the PERM model results. Abrams et al. (2007) pointed out:"Businesses evolve their response to risk and compliance along an ERM maturity continuum. They begin by complying in order to avoid penalties, progress through improving to optimize and sustain and finally achieve a state of continuous risk-based transformation where they can make use of compliance for competitive advantage."

However, the low model R-squared, the low power value, the low bivariate correlation did not support the hypothesis *H2b*: The perceived quality of communication among people (pqc) is positively associated with perceived value of the ERM implementation (perm). None of the other variables was supported overall or in any group. This means in general that the contribution to increase perceived value of ERM implementation is not associated with the KM variables used in this study.

6.2. Understanding of KM support to RM transformation and current circumstances

The previous sections showed the hypotheses results for the KM variables and RM variables. This section concentrates on analysing the impact of the results of this research in finding ways to improve the quality of Risk Management. The results contribute to finding solutions to RM organisation issues and goal achievement because financial institutions need to give priority to many actions in risk management daily work in order to provide reliable protection for the organisation. The results show that KM is likely to contribute to the quality of risk control and that the contribution to ERM is not significant. This has an effect on policies related to: technology, people, and general policies in terms of strategy and in terms of RM in particular.

The following sections describe the results in four main aspects of the RM context where KM processes influence the RM development. These four points refer to the value that KM could provide to ERM in the light of the global financial crisis and the required RM improvement. First, there is a review of the results in RM culture and RM errors; second, the concept of risk knowledge sharing and communication in RM; third, new directions of RM practice; and fourth the SECI model in RM.

6.2.1. Risk management culture and RM errors

In sections 1.1, 2.2, 3.1 and 3.2 it was pointed out that financial institutions evolved from specific product providers to holding organisations providing financial solutions to multiple customer segments with an important component of customer consulting services. Competitiveness is based on more risk exposure through more product and services and having more customer assets to manage. Thus, RM has changed as well and it has to be concentrated more on reducing the vulnerability of adverse events than on the prediction of the event only (Taleb et al., 2009).

Financial institutions had to deal with crises caused by expansion, lack of communication, reduced risk culture, reduced system functionality. For instance, the risk control of the product and its effects when a product is introduced to the market is likely to be improved using, in different steps, better knowledge sharing, risk information systems, etc, but the contribution to perceived value of ERM implementation will not be directly associated with these KM improvements. KM is an input and support to improve learning process and to develop the capacity to coordinate knowledge sharing across the organisation. Regarding to this Mun (2006) pointed out, " Before an organisation can learn to make tomorrow's forecast today, it has to learn from the lessons of yesterday."

Additionally, Mun(2006) presented criteria for instituting change to a RM culture where KM plays a central role, these points refer to: do not consider the change an academic exercise but the creation of standards for decision making, present how the competitiveness will improve, to present the RM black box as more transparent and accept other areas methods, improvements and influence on RM decisions.

The results of this research indicate that risk control is supported by the development of better risk management information systems functionality, better communication among people, better quality of web channel functionality and better quality of risk knowledge sharing. Risk control has to deal with mitigation of errors. Taleb et al. (2009) pointed out that six errors have been made by risk management. These errors are:

- We think we can manage risk by predicting extreme events
- We are convinced that studying the past will help us manage risk
- We don't listen to advice about what we shouldn't do
- We assume that risk can be measured by standard deviation
- We don't appreciate that what's mathematically equivalent isn't psychologically so
- We are taught that efficiency and maximizing shareholder value don't tolerate redundancy

The mitigation of these errors starts with risk knowledge sharing, communicating and understanding that the prediction of adverse events has not only to be the core of the RM practice. If extreme events appear, the need is to be prepared to handle the consequences. This means concentrating on improving the capabilities of reacting and controlling and taking into consideration that the past is not the rule to achieve similar results in the future. What is needed is understanding how the randomness affects the socio-economic variables and the effects on the organisation's result. In terms of the results of this research the previous point underlines the need to improve people's capacity to interact, to develop risk management information systems, risk knowledge sharing and web channel functionality, in order to provide tools to deal with risks, their effects and risk control.

The risk management information system functionality supports the RM processes and in particular has a positive effect on risk control. However, this value of the risk management information system is complemented by the understanding of the positive effect that sharing risk experience has in improving the mitigation of the errors in RM and provides an important value in dealing with potential dangers. Sharing risk experience needs better communication and effective collaboration. The decision-making tools are required but the need of "intuition" and "judgement" monitoring the models and results (Davenport, 2009) is important for improving RM practice in order to avoid decisions such as investing and securitizing subprime mortgages and loans and at the same time hedging the portfolio using credit default swaps.

These actions/decisions might occur due to not properly sharing risk knowledge or a lack of communication or deficiencies in the risk management information systems or web functionality. Long and Jagtiani (2010) pointed out three components "Market participants' overconfidence" in products without tests; this means no connection and shared information. A second point, "too big to fail" this means deficiencies in sharing knowledge and observing the real movements of the organisations. Third point, "issues related to corporate governance and principal-agent conflicts exhibited the function of firm's internal control and risk management system."

These errors can come as well from the integrity of data, people education, prioritization, or managing initiatives to improve RM practice or as Kloman (2008) indicated that RM has some blind spots: divinity of gods, rush of herds, black swans very improbable events, everything is wrong, error of success, academic pomposity. Kloman (2008) expressed: "In global risk management today, there is too little interdisciplinary interaction, too little searching for risk insights from other professions such as engineering and medicine" and referring to the academic support said: "The language is convoluted, opaque and abstruse, increasingly aimed at a narrow group of the cognoscenti" most of the practitioners do not understand anything.

A reflection about the errors in the RM processes indicates the need for learning from experience and sharing the risk knowledge to improve risk control. This is what Mum (2006) expressed about the Barings Bank experience:" This multimillion dollar institution was brought down single-handedly by Nicholas Leeson, an employee halfway around the world. Leeson was a young and brilliant investment banker...He was able to cover his losses through fancy accounting and by taking significant amounts of risk." Additionally, in RM there are knowledge components that need better understanding such as: the results of the models, simulations, understanding of the economic waves, correlation in products, assumptions, and data used.

Similarly, the better the way that potential dangers are communicated and shared, the better risk control, but this capacity of listening and understanding of experience needs a level of redundancy in RM practice, which is not a mistake (Taleb et al. 2009). Taleb et al. (2009) said redundancy could be a sign of inefficiency, but organisations need to be prepared for unexpected changes and to create metrics, strong enough, to measure the consequences and costs of any perceived risks.

Risk control is associated with the web channel functionality and the analysis of the web channel functionality variable shows that the intranet has been used to support KM as information repositories and "retain that knowledge within the company when employees leave." (Begbie and Chudry, 2002). The values of the intranet according to Begbie and Chudry (2002) are associated with "The intranet overcomes organisational hierarchies, formal communication policies, physical barriers and social groupings to move knowledge available to everyone." There is in RM a need to support users to find a user friendly intranet that provides what they need to perform in their daily actions. Equally, Kimmerle et al. (2010) bring a point that applies to RM practice. Individual and organisational learning are supported by intranets and the internet, and technologies that support work flow management with the creation of documents and patterns that have an influence on people and business processes.

6.2.2. Risk knowledge sharing and communication in RM

In sections 3.6 and 3.7 the review of people and process variables was performed and the results showed that not only the functionality of the risk information system and the intranet are associated with risk control but also communication among people, Moustaghfir (2009) expressed “The knowledge stock needs to flow through learning processes in order to be created, renewed, and leveraged.” This is aligned to communication and understanding of RM for making better decisions as Berends (2005) and Barcelo-Valenzuela et al. (2008) indicated. The identification of the problem to solve in terms of KM practice is to start with some groups and in growing the practices with other groups looking for new actions within areas where there is more knowledge to manage. This process was developed in order to prepare the RM stakeholders to better understand RM practice. This practice has been enriched by improved communication related to the RM knowledge sharing, which is represented by personal interactions, written contributions and communities of practices in RM such as Yi (2009) indicated.

Communication and knowledge sharing in order to the solve the issue pointed out by the Federal Reserve Chairman Ben Bernanke in his speech in May 2010 at the Federal Reserve Bank of Chicago’s Conference on Bank Structure and Competition:” One of the lessons learned from the current financial crisis has been the need for timely and effective internal communication about risks.”

Thus, the research results contribute to the development of a better capacity to deal with the RM processes before and after risks emerge and to develop the risk management information systems to support the diversified portfolio of services that the financial institution has, generating a wider risk exposure to control. The technology variables have a positive effect on the perceived quality of risk control showing that the functionality concept is an important one, for the risk management information system and web channel. Even though, the results suggest that none of technology variables have a significant effect on the perceived value of ERM implementation.

The demand for new solutions for developing markets and innovation makes RM problems grow. However, the effects of KM variables are perceived as associated with improving the quality of risk control more than the consolidation of the ERM culture and implementation. Moreover, the needs of management in financial institutions are associated with the concept of considering these organisations as risk and knowledge ones, where knowledge is created every time risks emerge. The need for a proper risk identification, risk evaluation, information consolidation and improvement of the risk analyst is part of the KM support (Glantz 2003; Crouhy et al. 2001; Panjer 2006; Abrams et al. 2007).

The point of finding risk knowledge sharing as a contributor to the RM processes, in particular to risk control, can be additionally analysed based on what Wasco and Faraj. (2005) pointed out "We find that people contribute their knowledge when they perceive that it enhances their professional reputations, when they have the experience to share, and when they are structurally embedded in the network." This result, in the context of this research, shows the importance of good communication means that allow support to others, capacity to communicate and develop an organisation which recognizes the value of risk sharing knowledge in documentation, the willingness to share, the access to experience within a proper environment for discussion and problem solving. One means for supporting risk knowledge sharing is the web-based network, as it is valuable for risk control according to the research results, and for sharing knowledge faster, with more people in various groups (Wasco and Faraj, 2005).

Therefore, the organisation needs to be able to develop activities where RM people can exchange points of view and can reach conclusions during meetings. The perceived quality of communication among people helps to achieve successful risk control particularly by providing motivation and openness to the reception of different views. Buehler et al. (2008a) indicated that four factors contribute to improve RM practice: quantitative professionals, strong oversight around the world, partnership heritage and business principles that are based on caring the reputation. KM can contribute to supporting the interaction of people from different geographical areas and to being involved in different types of risk analysis, to generating better risk knowledge sharing, better web channel functionality, better communication and better management information system functionality, as the results of QRC model showed. These factors embrace specific knowledge, quantitative knowledge and the value of having wider, deeper and global knowledge in the way it contributes to restructuring the risk control systems

The research results bring another consequence in the development of benefits for improving the quality of risk management: one is related to better solutions to the market and another one is to have better operational risk management. The evolution of financial institutions is framed by regulatory structures that transform the ways of doing business and take into consideration the gaps to fill in providing protection to all stakeholders. The new regulation takes into account the operational risk as a key factor of the RM practice. Operational risk is the risk that arises from various sources and one of these is the people intervention and the use of knowledge and capacities to interact. This research indicates that communication among people and risk knowledge sharing contribute positively to the perceived quality of risk control and, in particular, is likely to have positive effects on operational risk control.

The value of creating a culture through knowledge sharing is indicated by Rosendaal (2009) in particular through social identification in working teams. To this point Liebowitz (2008) said:" Much has been written in looking at how culture influence knowledge sharing or knowledge management practices." And Liebowitz (2008) identifies two "schools" those that introduce KMSs first that fit the organisation's culture and those that introduce knowledge sharing first and the KMS after. At this point the financial organisations have portions of KMS but it is likely to improve the RM practice through a better: quality of risk knowledge sharing, quality of communication among people, functionality of the risk management system and the web channel. Buehler et al. (2008a) add to the above point the concept of the creation of a RM culture. They summarized their views, related to the RM organisation, saying: "Success is closely linked to the culture that companies develop around risk." This culture is surrounded by techniques, technology, knowledge discovery from data, evidence to make decisions and the means to interpret and to provide outlooks for possible results.

6.2.3. New directions in RM practice in financial institutions

In sections 2.4 and 2.5 some examples of KM applications in financial institutions were introduced in the same manner as KM and RM could be working together to support RM processes. The culture of RM has roots in the financial institution business. As Buehler et al. (2008) said "Many important innovations in risk management originated in the banking and securities industries.... First, financial institutions are in effect risk-intermediation business... Second, these industries are rich in data... Third, and perhaps the most important, they are typically highly leveraged and are monitored by regulators who...pushed for improving risk management."

Moreover, Upton and Staats (2008) pointed out, "Instead of building systems that are legacy from the day they are turned on, managers can and should develop systems that can be improved – rapidly and continuously – well after they've gone live. Over the past decade, we've studied the design and implementation of enterprise IT systems and assisted numerous firms with the process." The KM initiatives of data mining, communities of practice, conceptual maps, and knowledge portals are part of the influence that communication, knowledge sharing, and functionality of the technology systems have in risk control. Part of the culture that might contribute to risk control and ERM is based on risk analyst interaction sharing experience and solutions to RM problems such as: diversified and wide risk exposure, risk analysis with an integral view and connectivity of resources.

The RM practice creates tools for risk measurement, tools that need to be understood by the RM community in the organisation and other stakeholders, concepts such as: economical capital, expected loss calculation, value at risk, stress testing etc. The Bank of Montreal (BMO) in Canada expressed, in its 2009 report, which it was in the search of: enhancing risk culture or risk ownership and accountability. All of this enhancing risk transparency is related to risk analysis, including enhancement of discussions to provide greater insight and oversight with improved clarity in information and reports. To get there, the process needs, as BMO said, the development of new leadership forms to discuss risk return trade-offs and emerging risks, establish an IT strategy in support to RM foundations, and here is where the ERKMAS bases (See Section 6.3) indicated in this research can contribute more.

To complement the previous point and the value of the KM results in a RM culture the description of the concept of creating risk culture in the BMO shows there is room for the KM variables application, because the program comprises actions where the KM variables and actions are required. The KM variables that were found contributing to risk control can support the principles that banks want to promote and use for RM. According to the review of the annual reports of some banks (BMO, Royal Bank, TD Bank), the principles are grouped as follows:

- Transparent and effective communication that is related to the variable perceived quality of communication among people *pqc.*
- Integrated risk and control culture. Risk management integrated in daily routines, decision making and strategy. This point is related to the variable perceived quality of risk knowledge sharing *qrks* given th multiple risk areas that are involved across the RM organisation such as in the risk evaluation process is required.
- Use risk measurement. Related to the support coming from risk management information system functionality *misf.* The organisation looks for the means to support measurement methodologies that keep same principles, data and assumptions across the organisations.
- Enterprise wide RM scope. Related to support that can provide the web channel functionality, *wcf*. This is to have the means to connect people and to spread the means for actions in RM processes.
- Enhanced accountability
- Independent oversight

These points above indicate what from KM variables and actions is required in the bank:

- Engagement RM and business groups, transparency and risk adjusted return
- Open and timely horizontal and vertical information sharing and discussion
- Escalation of potential or emerging risks and areas of disagreement

- Continuous and constructive challenging of decisions and actions
- Effective communication of risk appetite
- Active learning from actions
- Objectives with risk appetite
- Performance risk measures based

These principles that the organisations adopt individually emphasize some points such as in the Royal Bank of Canada (RBC Annual report 2008) indicated, where the levels of governance and risk management include the interconnection of: top level ERM framework, risk specific frameworks, enterprise risk policies, multi-risk enterprise risk policies and business segments specific policies. This means starting from the most general and arriving to the specific and aligning, connecting and integrating actions where risk knowledge sharing and the ERKMAS have room to support risk control.

With regard to the KM variables and RM relationships, the Davenport and Prusak's view (1998) is appropriate. Knowledge for them appears from the interaction of four elements that include experience, people, processes and organisation. The results of the research indicate that these elements; such as,, people as repositories of knowledge and the organisation information systems can contribute positively to risk control. Earl's (2001) presentation of the KM schools suggested that the possible intervention of KM in the RM world would be with a focus on the technocratic and behavioural schools in financial institutions. The reason for this is that in RM organisation there are relationships with quality of risk control based on people, communication, risk knowledge sharing, risk management information systems and intranet support. The RM process is organised by types of risk, risk processes and by geographical regions and there are activities in which people, technology and processes act together; such as, traders and their interaction with RM analysts every morning (Crouhy et al. 2001)

From the identification of the KM variables association with risk control and using the views of Alavi and Leidner (2001) the results are aligned with the definition of KMS as an information system to manage organisational risk knowledge and with the concept of the process of sharing knowledge where improvement of communication, interpretation and the sharing of results of risk management analyses contribute to decision and actions (Marshall et al.,1996).

6.2.4. Revisiting the SECI model in RM

Finally, from section 2.3.1. and 2.5 the results under Nonaka's SECI model allow for understanding and aligning the flow of risk knowledge for risk control and the improvements of the organisation actions. Actions to improve the KM variables that appear significantly related to risk control.

- Socialization: is represented by the communication among groups of risk management. This is important for risk control because of the need for social interaction among the RM employees and shared risk management experience in order to develop and analyse solutions.
- Combination: risk knowledge sharing can be promoted to provide the combination of knowledge needed in the risk control process. The promotion is represented by actions that unify terminology, merge, categorize, reclassify and synthesize risk concepts and knowledge in the risk management processes.
- Externalization: is represented by the use of experiences of different areas. The support from a better functionality of the risk management information system and the web channel allows the articulation of best practices and lessons learned to use them in problem-solving in multiple areas of risk management.
- Internalization: Learning and understanding that come from discussions in meetings, forums and quantitative-qualitative risk management reviews that are performed in the RM practice gain impact in the risk control with better risk knowledge sharing, better communication among people and the support of better functionality of risk information systems and web channel..

The use of information technology (IT) in RM to support the dynamic of the SECI model (Chatti et al. 2007; Alhawary and Alnajjar 2008) is a way to develop the RM practice. This IT support having the proper functionality of the risk management system and the web channel is a means to support risk control, different kinds of risk and access to data, applications, collaboration and experiences in RM.

6.3. Possible bases of an ERKMAS design

Crouhy et al. (2001) proposed various particular characteristics of the risk management information system. The results of the research indicate that functionality enhancements to a risk management information system and to the web channel are more likely to improve the quality of risk control. At the same time RM activities involve people from different areas and in charge of different risks, who need to interact, share risk knowledge and use common technology means in order to perform their work.

As the previous section showed from the results of the research there are elements to provide bases to evolve from a RMIS (Section 2.2.6 and 3.8.1) to an Enterprise Risk Knowledge Management System (ERKMAS) design. The ERKMAS, through better communication among people, better risk knowledge sharing process, and better functionality in the risk management system and web channel, supports KM processes and RM processes.

From the KMS point of view an important aspect to note is that in reviewing the research framework the KMS was depicted as a "kind of information system" that support knowledge management (Alavi and Leidner 2001) and the concept as a socio-technical system (Lehaney et al. 2004). The research results suggest that the KMS in a risk management environment is influenced by the quality of people communication, the quality of risk knowledge sharing and the functionality of the risk knowledge management system and the web channel functionality. Thus, risk control is influenced by people, process and technology.

Therefore, the ERKMAS should be based on the Socio-technical approach (Figure 6-1). This means that based on the results, people and technology are factors for improving risk control and that the ability of people to communicate and share knowledge will complement the improvements of the functionality of the technological components. Massingham(2009) pointed out that the risk management "on decision tree methods are ineffective" and this means the need to search for new methods to deal with risk and therefore the need of creating the ERKMAS. The two components that Massingham (2009) proposes are related to the analysis of “environmental uncertainty and cognitive constraints.” This author identifies some matrices for risk assessment and risk identification: severity and frequency, which are used in RM practice.

However, Massingham (2009) does not include in the framework the important components that this research put in evidence; such as the development of the means for improving risk knowledge sharing and collaboration to support risk control. The methods of rational treatment exist in RM and the value of them is in the proper use by risk management staff; however, what is missing is the people, process and technology integration and development. Gregoriou (2010) indicates the points where RM has been ineffective and pointing out: problematic lending practices, the low robustness of the risk management systems to “cope with subjective estimates and personal judgement need to be sufficiently robust to be able to compensate the negative extremes.” Another point is the correct use of metrics and key indicators. There is room for developing better means to address the lessons learned “As a “lesson learned” from the recent financial crisis, it is submitted that in the future, risk metrics must take into consideration what truly is at risk, and what the major risk drivers are and will be.”

Gregoriou (2010) continues saying that there is a “Meta Risk” referring to the assumptions and to the “failure in quantifying risk appropriately and reflecting the right assumptions.” Additionally, he pointed out the need of reviewing “the perfect market hypothesis” the market is not perfect and there are several anomalies. Finally, Gregoriou (2010) indicates the importance of having a clear and proper evaluation of the results and indicators that are presented by Rating Agencies and Financial Reporting.

This Gregoriou (2010) points indicate the importance of risk judgement the capacity to create and share risk awareness among the RM staff and the capacity to communicate with others. Regarding this Bhidé (2010) points out “No single individual has the knowledge to make those adjustments; rather, it is widely dispersed across many individuals… therefore, individuals who have on-the-spot knowledge must be to figure out what to do.” Therefore the bases of the ERKMAS are in the creation of capabilities of people and organisation to collaborate and to develop the people’s judgment trough the proper use of documents, meetings, collaborative activities, models and multiple source of data in structured and unstructured formats. Bhidé (2010) continues saying " In recent times, though, a new form of centralized control has taken root that is the work of old-fashioned autocrats, committees, or rule books but of statistical models and algorithms. This has been especially true in finance, where risk models have replaced the judgments of thousands of individual bankers and investors, to disastrous effect."

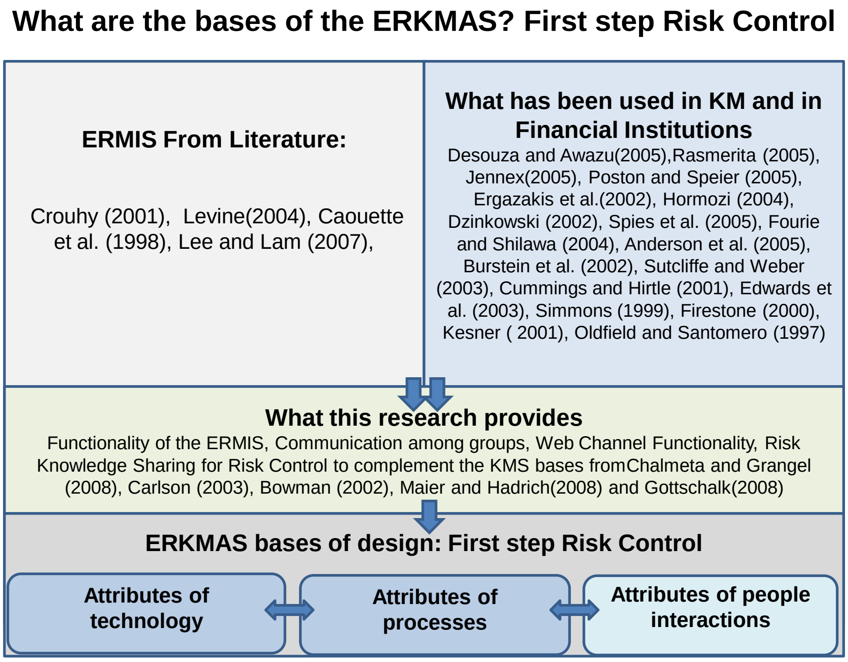


Figure 6-1 Bases of ERKMAS with risk control as first step

Figure 6-1 represents the elements that are identifying an ERKMAS. First based on the literature review it is possible to identify what people considered as a need of the architecture in RMIS, additionally the literature indicated the current use of tools, technology, methods in RM and KM in financial institutions, which under this context act independently. The design of the ERKMAS needs to group these elements and to identify a common framework of design. Based on the results of the research it was identified that means and communication methods among people, knowledge sharing capabilities and functionality of web channel and a risk management information system should be part of the design components of the ERKMAS. Components that would include technological elements and people oriented solutions.

From section 2.3.4 the articles of Chalmeta and Grangel (2008), Carlson (2003), Bowman (2002), Maier and Hadrich (2008) and Gottschalk(2008) provide insights for the KMS design, which applied to RM and can be summarized as follows: identification of risk knowledge and the structure to organise it, store and retrieve, using technologies for accessing and servicing multiple users with various methods and tools. It should be kept in mind that there are relationships of people to people, people to documents, and people to systems that have to be taken into consideration for the design.

Based on the above points and the research results, Figure 6-2 summarizes the bases of the ERKMAS. The literature review and the results of this research provide evidence for identifying the attributes for a risk management system that contribute to a better risk control. The first part of the Figure 6-2 shows that the results of this research are connected to RM processes and shows what the literature indicates as the best for having a risk management information system. The second part of the Figure 6-2 identifies what is necessary to use from the previous experience. However, Figure 6-2 is only valid for risk control given there is no clear correlation between the KM variables and ERM perceived value; but, the principles of communication, knowledge sharing and functionality can be extended enterprise-wide and to provide the bases for system integration which is one of the main issues in financial intuitions as was mentioned in Chapter 1.

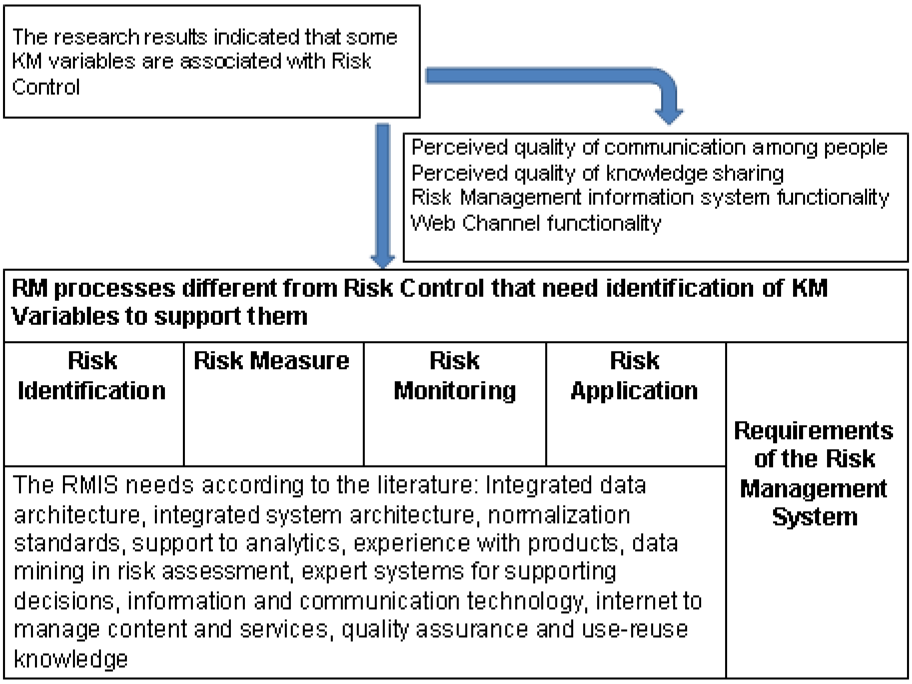


Figure 6-2 Summary of the bases of ERKMAS design (First step Risk Control)

Once it is clear what the bases of the system should be, which were based on the literature review and the research results, it is possible to identify what the answers should be for a system design that support the KM processes. For each KM process the KM tools, in the context of risk management, are identified from the current practice in financial institutions but with an emphasis placed on KM processes focussing on the RM problems. The evidence of this research shows that financial institutions have developed some solutions applying to people oriented items, which might be used for the ERKMAS design..

Figure 6-3 summarizes the basic components of the ERKMAS in the sense that the system takes the experience with products, with operations and customer satisfaction to convert them into solutions for the internal and external customers based on the knowledge management processes (Alavi and Leidner 2001) For instance knowledge creation might be represented by new ways to price the products, knowledge storage and retrieve through the design of the data architecture and the means to access this data. Regarding knowledge application it gives the possibility of getting solutions to problems through means of business intelligence, competitive intelligence, expert systems etc. that might provide insights in risk classification, processes improvement and customer service. Finally, through structuring knowledge transfer and knowledge sharing the RM people will be able to organize work with different risk groups and. with different views of the problem-solving process.

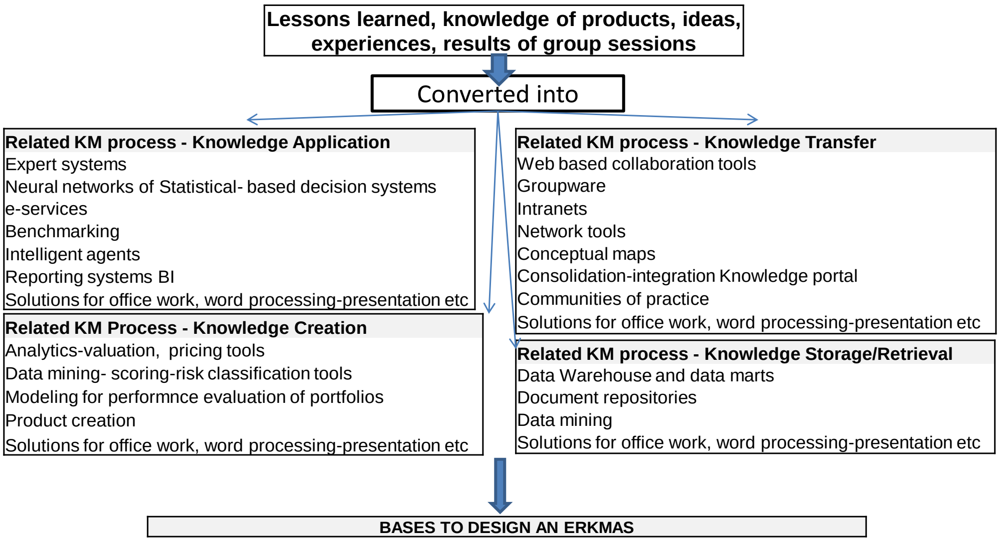


Figure 6-3 Basic components of the ERKMAS and KM processes

6.3.1. Some aspects about the contribution of the ERKMAS basic design

The Risk Management process involves a "collection of processes, people and systems aligned for the purpose of measuring, managing, monitoring, and controlling risk exposure." (Levine 2004). The ERKMAS basic design takes into consideration this alignment, introducing the identification of the value of a system having functionality that support knowledge sharing and risk management information for control. The ERKMAS design contributes to identify the components of the system that through a data and enterprise architecture handle the enterprise needs of the RM processes. These process deal with high volume of data and intensive computation. The web channel functionality might facilitate the design of interfaces that provide access and interaction of people in the development of their tasks and responsibilities. The other aspect that the web channel contributes is providing access and connectivity to multiple applications that the risk management information system has.

The ERKMAS design requires flexibility in the sense (Levine 2004) of adaptation to regulation. Compliance is one of the priorities in financial institutions, Basel II introduced requirement the new Basel III has new requirements and the particular case for insurance companies through Solvency I and II introduce requirements for the information systems. The ERKMAS basic design includes functionality of the web channel that based on the new technologies might include the support to work flow, project management and support the particular process of documentation, records keeping and learning and development.

One of the aspects that is a challenge in the ERKMAS design is the adaptation to products. The reason is the variety of products and support required by them. The data-marts and applications to control products are multiple and the user, the same as the control process, requires capabilities for user access and data handling. The data storage capabilities is associated with the analytical work that risk management people need to perform in order to keep the risk control of the operation.

Now in terms of the system development cycle (O'Brien 1996; Shelly et al. 1998) the results of this research provide insight in the systems planning phase through the identification of the requests by the business and regulators. From the point of view of risk control, identification of the problem refers to the business needs and to fill gaps because of diversity and business complexity. From the regulators risk control is the basis for keeping the organisations providing services to all stakeholders. In the system analysis phase the system requirements appeared through the literature review and the relationships of the variables describing risk control and knowledge management. The requirements mainly based on technology, data model and human interaction based on communication and risk knowledge sharing.

And in the system design phase the results of this research indicate part of the answer of what the system has to do and to prepare the answer of how people and technology should interact in order to improve the use of risk knowledge in the risk control process. The literature identified (Levine 2004; Crouhy et al. 2001) the need of having real time access and processing of data, messaging, risk capacity for analytics work embedded in workflow support, review and control of exposure, performance evaluation of products and reporting.

The question of investment in the ERKMAS, according to the review (Section 2.3.6 of IT value) will provide value to the organisation through productivity and customer satisfaction (internal and external). However, the investment through an in house built system or to buy is a decision based on the systems availability through a gap analysis between the requirements and what is commercially available, The reason is that software solutions are concentrated mainly on the data and analytic part of risk management, specific risk management areas (Crouhy 2001) but not in the human interaction and a more integral view of risk across the organisation.

6.4. Summary

There are several contributions to the research results for improving RM practice:

First, to identify KM variables that are related to the quality of risk control (perceived quality of risk knowledge sharing, perceived quality of communication among people, risk knowledge management functionality and web channel functionality; second, to identify that the KM variables are not related to the perceived value of ERM implementation; third, the basis of the ERKMAS bringing together the literature review about risk management information system, the results of the research and the tools used in KM and risk management in the financial institutions.

There is an important revelation that specific knowledge needs to be complemented with the capacity to understand trends and to use the experience to solve RM problems. However, the analysis of the survey data and the literature review warns not to anchor the perspective of risk management to one particular experience only, because the solutions could come from the understanding of risk developing better communication and managing the risk perception from people with different views and from multiple disciplines (Champion, 2009).

The next chapter includes the conclusions, limitations of the research and possible new research options to follow.

7. Chapter Seven Conclusions, limitations and new research opportunities

Eight hypotheses have been tested in order to relate KM concepts to the perceived quality of risk control and the perceived value of ERM implementation. A survey obtained responses from 121 risk management staff in financial institutions. Eight explanatory variables were used for both dependent variables: perceived quality of risk control and for the perceived value of ERM implementation. These comprised three variables relating to people (organisational capacity for work coordination, perceived quality of communication among people and interaction in the design of the risk management information system), one relating to process (perceived quality of risk knowledge sharing) and four related to technology (web channel functionality, risk management information system functionality, perceived value of information systems integration and quality of network capacity for connecting people).

7.1. The aim of the research and research objectives

The aim of this research was to contribute to the RM and KM literature by identifying the relationships between the variables describing the KM processes, in particular knowledge sharing and the RM management variables: perceived quality of risk control and the perceived value of the ERM implementation.

To achieve this aim four specific objectives were formulated: the first specific objective was to identify the knowledge and risk management constructs and their related items to use as a basis for research in the field. An exhaustive review of the items that could be related to the construct was presented and given the Cronbach's alpha results the items described the construct in a reliable way.

The second specific objective was to identify and put together existing work in each discipline (KM and RM) where there are commonalities in application to financial institutions . This review showed potential communalities between the two disciplines. Related to this objective, the research identified points of knowledge management where there are activities in financial institutions the same as gaps of knowledge that there are in risk management in the financial institutions.

The third specific objective of this research was to seek the KM variables that can influence the perceived quality of risk control and the perceived value of ERM implementation. The findings showed that four of the eight variables analysed have a significant positive association overall with the perceived quality of risk control. These are: one people variable (the perceived quality of communication among people), the process variable (the perceived quality of risk knowledge sharing) and two technology variables (risk management information system functionality and web channel functionality).

In stepwise regression, the variable perceived quality of risk knowledge sharing accounted for by far the largest part of the variation (31.3%) in the dependent variable perceived quality of risk control. Risk actions, decisions, experiences that people have dealing with different risks when they are shared develop in the different RM groups awareness and warning signals as input for the risk control process. According to the results, this means that actions improving risk knowledge sharing are likely to have the most positive effects on the perceived quality of risk control.

The other four variables: organisation capacity for work coordination, people's interaction for risk information design, perceived value of information systems integration and quality of network capacity for connecting people, have positive correlations with perceived quality of risk control, but did not have a significant association in either the mutliple or stepwise regressions. However, they do each have significant positive associations with at least one group of staff (See Table 6-1). Thus, the variables that were not associated overall with risk control were associated for some groups of respondents and all hypotheses were supported for some groups.

The only KM variable associated with the perceived value of ERM implementation was the perceived quality of communication among people; however, the R-squared was low (0.09) and the power was below 0.8 and the hypothesis of the relationship between perceived quality of risk communication and perceived value of enterprise risk management was not supported overall. No other variables overall or within groups were found with a significant relationship to the *perm* dependent variable. In particular, the perceived quality of risk knowledge sharing was not found to be significantly associated with the perceived value of the ERM implementation. This suggests that increasing actions in this regard of risk knowledge sharing is not likely to improve the perceived value of ERM implementation.

The fourth specific objective was to identify the bases for supporting KM in RM through a KMS design (ERKMAS). The ERKMAS design is suggested using the literature review and the identification of knowledge management system concepts that are associated with risk control and ERM implementation. This objective keeps the premise that financial institutions, as a knowledge and risk based business sector, require the support of the RM processes through an ERKMAS. The KMS and RMIS (to create the ERKMAS) might then be designed and structured, based on the literature review and findings. The results that indicate the positive relationship between the risk control and the KM variables to use in the ERKMAS design were: perceived quality of communication among people, web channel functionality, risk management information system functionality and perceived quality of risk knowledge sharing. The potential design allows people connection, capacity for sharing risk knowledge and information systems to develop the daily RM work.

The ERKMAS, which join risk and knowledge management processes, give a much stronger basis for the organisation in order to improve quality of risk control and the guidelines to build intranets that provide access to resources, data, applications, collaboration areas that facilitate interactions among groups, support to risk analysis, modelling and joint work with multiple groups. However, the results showed that the first step to use KM variables in RM is on the process of risk control and that ERM analysis requires further investigation.

The ERKMAS design has the challenge of the integration of collaborative work with the capabilities of modelling development and the judgement development with the proper use of a data architecture that compile various sources and formats. The ERKMAS should support the organisational performance with the improvement of what Zack et al.

(2009) indicate as a "gap exists between KM practices that firms believe to be important and those that were directly related to organisational performance." Even though, the relationship between the financial performance and KM practice is not found. The KM practice as a support of the RM practice through a proper ERKMAS design is expected to contribute to a better organisational performance.

As part of the problem solutions the contribution of this research is in complementing and providing a reference to the programs that financial institutions have in order to develop RM culture. Some banks like the Deutsche Bank presented in its Annual Report 2009 activities related to KM. The bank has invested in the Deutsche Knowledge Institute, in order to develop training and apprenticeships programs, fostering creativity and enabling talent. This program is an answer to the need of managing the wide variety of the business that requires identifying, measuring, aggregating and managing multiple risks and allocating capital among business property.

The continuous need to refine risk management practice has become particularly evident during the financial crisis and the need for better risk knowledge sharing and support systems has been evident. The Deutsche Bank pointed out: "We manage credit, market, liquidity, operational, business, legal and reputational risks as well as our capital in a coordinated manner at all relevant levels in our organisation." This statement provides clarity of the search of coordination and better understanding of the various risk types and means for risk control where the KM variables identified in this research will contribute to develop the RM practice.

The research provided evidence for considering that KM and RM processes should be aligned to achieve better RM results in risk control. Moreover, recalling the concepts of financial institutions as risk and knowledge organisations what the results indicate is that not only interpret the meaning of RM information is needed but also the unmanaged of organisational knowledge (Marshall et al. 1996) through better risk knowledge sharing, better risk management information functionality, better communication among people and better web channel functionality. Therefore, what financial institutions require to do: on the one hand to improve the capacity to deal with risk and its potential damages, when a risk emerges and on the other hand, to understand that models in RM are not the decision-makers, people are (Champion, 2009).

Based on the previous surveys (Table 3-1) the main points of RM are related to role of the board, the flow of governance through the organisation and the improvement of the decision-making process. This research complements the insights of the previous surveys showing the specific actions on systems, people and KM processes.

7.2. Contribution to knowledge

The contribution to the knowledge of the application of KM to RM through the relationships identification is summarized as follows:

This research contributes to the knowledge in the field of knowledge management in three main ways: First, providing items and variables that can be used for further research in the field of KM and RM. Second, in a general way identifying how knowledge management can be applied to a business process: risk management Third, in the specific way identifying the variable relationships between knowledge management and risk management.

The items, the variables and the scales used in this research provide a contribution for the future of studies in the field given the reliability results that the items have in each construct. The literature review provided a selection and consolidation of examples, concepts used and bridges built between the two of the most important strategic areas of a financial institution. The review of KM approaches in financial institutions and the identification of KM and RM interdependencies in financial institutions provide guides to new studies in the field particularly the inclusion of the knowledge management concepts as part of potential areas of improvement when crisis are in place.

The observation of how organisation components, risk and knowledge are interacting for structuring and supporting the firms operation show the connection in order to create sustainable advantages.Regarding the first point above the knowledge management literature now counts with a set of items and variables that are possible to use in the description of KM and RM relationships, or in a general way, to describe how KM might be applied to RM. There is a scale developed that provides bases to further studies. Additionally, in the process of this items and variables identification this research shows the way as financial institutions have been approaching KM and in some cases KM in RM in an isolated way with very specific purposes.

From the point of view of knowledge management applied to a business process, particularly risk management the contribution was in the identification of the knowledge management programs that financial institutions have, the dispersion of these programs and the reduced spectrum of knowledge management directly in risk management. Liebowitz (2006) analised the lessons learned in knowledge management implementations. The point that he brought to the analysis is what he called “Embed KM into Daily Work Life”. In a financial institution the work life is to deal with risk in all forms: credit, financial, operations strategy etc. Liebowitz (2006) continues saying that the KM system features have to be push and pull using for example the intranet and promoting an active knowledge mobilization.

This research presented the opportunities and observed the principles to embed knowledge management in the risk management process, observing that top-dowm and bottom-up approaches in the risk knowledge dissemination can provide value to the stakeholders. In Tanriverdi’s article (2005) indicates that “The KM capability creates and exploits cross-unit synergies from the product, customer, and managerial knowledge resources of the firm. These synergies increase the financial performance of the firm.” In particular to support the search of these synergies among departments in charge of different risks or risk processes. This research enhances the search of the variables influencing the risk control performance.

The specific identification of the relationships between KM variables and RM variables provides the first indication of how to start with the inclusion of KM in the daily work life for the risk management process. This is possible because the results suggest that there are some variables that are important for the ERKMAS design that can support RM processes. The web channel can be used as a means to share risk knowledge in order to improve risk control Thus, this research complements the Poston and Speier’s(2005) study about the effects of the content quality and the way to access this content in the usage of the system. This means that this research identified requirements of the system design and variables influencing risk control using an ERKMAS that will be used if there is quality of the content and its search.

The empirical evidence that this research shows support for the specific case of RM some of the features that Samiotis et al. (2003) included in the KMS description, They indicated the importance of including the business process elements, the ability to support communication and collaboration, offer virtual working space and mobilize experiences from different practitioners.

Finally, this research provides evidence on the no association of the KM variables used with perceived value of ERM built. From this point new research might include new components of the ERM value that refer to the evolution of this concept in risk management and search for new relationships.

7.3. Limitations of the research

There are some limitations to the research process. Validated scales were not available for any of the variables analysed, so there is no way to be certain that the constructs definition was totally clear for all of the participants in the research, given the application of multiple RM concepts and activities that people have working for different risk management processes.

Also, the web-based nature of the survey may have reduced the response rate from older (and perhaps more senior) risk management staff, for instance there are 33 data points that indicate more than 10 years of RM experience.. The geographical distribution of the respondents can be a factor influencing results because of concentration in some countries and possibly the degree of maturity in RM might be different. Additionally, the time when the data were collected was in the beginning of the financial crisis and the effect of the decisions and actions were not capture in the study. Finally, the identification of the size of the institution in which the RM employee works might be a good guide in understanding the level of development and sophistication in RM practice.

7.4. Areas of future research

This study points to a set of questions for new research in order to find more and clearer relationships between RM and KM. One of these is related to the concept of information system integration, which unexpectedly revealed a negative association with the perceived value of ERM implementation, albeit not a statistically significant one. There may be a difference between top-down business needs and bottom-up user perceptions here. In Venters's article (2010) he suggested that in a KMS the technology's properties are best used "to maintain the technology as neither stabilised nor rejected." On the other hand, there is scope to identify value in ERM that is related to strategic competitiveness, communication channels and communication with stakeholders, means used to transfer and to share risk knowledge***.***

The relationship analysis of additional ERM benefits and KM variables plus the ERKMAS structure to support the RM processes are priorities. The search for relationships directed to particular RM areas is valuable, for example: the understanding of the outcomes and the process to commercialize products based on models, validation of assumptions and development of risk indicators to support decisions and avoid crises.. Equally, RM needs studies directed to identify the soft part of the risk management and the influence in the decision making process plus the capacity that people develop their activities in a better and reliable environment.

Even though the issues of risk management touches all areas in any organisation, particularly financial institutions, enterprise risk management, risk control, risk measurement and governance need better strategic knowledge, customer knowledge, operational knowledge, logistic knowledge. An important area of research is the potential lack of good risk management communication with the board of directors and executives. The communication among people was a significant variable to perceived quality of control and not with the perceived value of ERM.

Another area of analysis is the influence of the business environment in the financial institution, the RM group and in general the influence of the organisational culture on the

RM and KM relationships. Buehler et al. (2008b) pointed out the risk culture in organisations has limited capacity of dialogue between the board and management and that there is a set of tools with high level of complexity and silo oriented that reduces the capacity of the organisation to react to adverse events and to understand risk attributes and ways to manage them. They emphasise the need for developing understanding of the influence of risk in the decision making process.

This research provided insights regarding the relationships of KM variables in the world of risk control and the integral view of RM called ERM. However, there is a lot of work to perform in order to understand risk management and management under risk or as Nohria and Stewart pointed out in 2006, that during the twentieth century management emphasized on risk and that "Uncertainty and doubt push the boundaries of management as we know it....the flight from uncertainty and ambiguity is so motivated, and the desire to reduce what is fundamentally unknowable to probabilities and risk so strong, that we often create pseudo uncertainty." This is an open window to search and to develop the capacity to manage knowledge for risk management in the way that Bronowski said (Quote taken from Science Findings 2005) "Knowledge is an unending adventure at the edge of uncertainty" and to reduce the biggest risk as Taleb et al. (2009) called, "Remember that the biggest risk lies within us: We overestimate our abilities and underestimate what can go wrong.". They went deeper in their views and pointed out, "The ancients considered hubris the greatest defect and the gods punished it mercilessly. Look at the number of heroes who faced fatal retribution for their hubris: Achilles and Agamemnon died as a price of their arrogance."

7.5. Summary of the study

This study was based on the identification of items and variable construction in order to identify the relationships between KM variables and RM variables. For this relationship identification a survey was designed and applied to RM employees in financial institutions. The data gathered was analysed through exploratory data analysis, multiple and stepwise regression.

This research has shown that in the financial services industry four KM variables: Perceived quality of communication among people, perceived quality of risk knowledge sharing, web channel functionality and risk management information system functionality have a positive relationship to the Perceived Quality of Risk Control variable and that none was significantly related to the Perceived Quality of ERM implementation. The study indicated that in some demographic groups other variables had a significant, relationship to the perceived quality of risk control such as integration of the information systems by the credit risk group. For the perceived value of ERM implementation no variable was significant in any demographic group.

Using the results and the literature review the basic design of an Enterprise Risk Knowledge Management Systems was suggested in order to provide support to the RM processes.

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9. Appendices

9.1. Questionnaire

Knowledge Management applied to Enterprise Risk Management
Survey about risk knowledge sharing for implementing ERM

1: What is the area of risk management that you work in? Please choose only one of the following:

Market risk
Operational risk
Credit risk
Currency risk
Legal/regulatory risk
Capital risk
Other

2: What is the process of risk management on which you spend most work time? Please choose only one of the following:

Risk identification
Risk hedging
Risk transfer
Risk quantification
Risk classification
Risk evaluation
Risk mitigation
Risk mapping
Other

3: How long have you worked in your current position? Please choose only one of the following:

Less than 1 year
1 to less than 3 years
3 to less than 5 years
5 to less than 10 years
More than 10 years

4: How many years of experience do you have in Risk Management? Please choose only one of the following:

Less than 1 year
1 to less 3 years
3 to less than 5 years
5 to less than 10 years
More than 10 years

5: Please provide your level of agreement with regard to the integration of the information systems in the organisation. Please choose the appropriate response for each item:

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
The same standards are used					
A common data structure is used					
A common data warehouse is used					
A common user interface is used					
A common application access is used					
A common report system is used					

6: Please indicate your level of agreement with regard to the coordination of work among different areas in the organisation. Please choose the appropriate response for each item:

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
The organisation encourages interdisciplinary work					
The organisation encourages interdepartmental work					
There are good web based collaboration tools					
People are willing to work with multiple groups					
There are guiding principles for working with different groups					
There are standards for using collaboration tools					

7: Please identify your level of agreement with regard to risk knowledge sharing in the organisation. Please choose the appropriate response for each item:

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
People are willing to share risk knowledge					
The availability of documentation is good					
The access to experience is good					
There is an appropriate environment to discuss results interdepartmentally					
There is an appropriate environment for the creation of shared solutions					

8: Please identify your level of agreement with regard to the risk control process in the organisation. Please choose the appropriate response for each item:

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
The risk mitigation tools are good					
The risk assessment process is good					
The risk transfer process is good					
The risk product evaluation is good					
The risk aggregation analysis is good					

9: Please indicate your level of agreement with regard to the functionality of the risk management information systems in the organisation. Please choose the appropriate response for each item:

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
The systems provide support to the risk modeling process					
The systems provide access to experience in risk analysis					
The systems provide adecuate data management support					
The systems provide capacity to improve work flow					
The systems provide capacity to work with multiple groups on a project					

10: Please identify your level of agreement about the network capacity for connecting people in the organisation. Please choose the appropriate response for each item:

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
There is an enterprise portal structure supporting interdepartmental work					
There are collaboration tools easily available					
People use web based workspaces for working on projects					
Solutions are created because of multidepartmental work					
Sharing my work with others is easy					

11: Please indicate your level of agreement with regard to the communication in the organisation. Please choose the appropriate response for each item:

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
The communication between the Risk Management groups is good					
The communication within my Risk Management groups is good					
The communication environment fosters the interchange					

of different points of view					
There is a good capacity to get conclusions easily during meetings					
The communication environment promotes team work					

12: Please identify your level of agreement with the following statement Please choose the appropriate response for each item:

In the design of the risk management information system the people interaction from different risk management areas was good

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

13: Please identify your level of agreement with regard to the Risk Management Intranet quality in the organisation. Please choose the appropriate response for each item:

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
The Risk Management Intranet provides access to collaboration tools					
The Risk Management Intranet provides access to all applications used in risk management					
The Risk Management Intranet provides access to the proper data					
The Risk Management Intranet facilitates interaction in problem solving process					
The Risk Management Intranet supports communication among risk management people					
The Risk Management Intranet supports risk management controls					

14: Please identify your level of agreement with regard to the value of Enterprise Risk Management (ERM) Please choose the appropriate response for each item:

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
ERM improves collaboration					
ERM promotes our experience sharing					
ERM reduces the number of times we reinvent the wheel					
ERM improves the quality of data					
ERM improves our interdisciplinary work					
ERM improves our interdepartmental work					
ERM improves our understanding of model results					
ERM improves our problem solving process					
ERM improves our capacity of mathematical modeling					

9.2. Tables descriptive statistics

rmexp=1

Variable	Mean	Std	Variance	N	Lower	Median	Upper	95th
isi	-1.405	4.257	18.119	4	-4.733	-0.325	1.923	2.002
cwc	1.668	5.283	27.911	4	-2.589	1.378	5.926	7.866
qrks	1.457	3.104	9.638	4	-1.187	1.401	4.100	4.645
qrc	3.143	4.812	23.154	4	-0.053	2.905	6.339	9.241
misf	0.316	5.498	30.225	4	-3.670	2.157	4.301	4.301
nccp	1.963	4.780	22.845	4	-0.712	3.641	4.639	5.638
pqc	3.571	3.289	10.820	4	1.644	2.742	5.498	8.254
iis	0.304	1.133	1.283	4	-0.262	0.871	0.871	0.871
wcf	3.519	3.204	10.264	4	0.849	2.987	6.190	7.255
perm	4.503	7.960	63.360	4	-0.401	2.249	9.407	15.949

rmexp=2

Variable	Mean	Std	Varianc	N	Lower	Median	Upper	95th
isi	0.244	5.223	27.284	15	-3.404	0.209	4.538	9.813
cwc	0.020	4.609	21.241	15	-1.866	2.064	3.217	4.424
qrks	-0.066	4.334	18.783	15	-3.924	1.514	3.644	5.730
qrc	0.358	4.133	17.085	15	-2.368	1.060	3.319	9.241
misf	-0.350	5.646	31.872	15	-5.112	2.125	4.301	5.322
nccp	0.230	5.155	26.573	15	-3.025	1.747	3.665	5.765
pqc	1.709	3.196	10.216	15	-0.476	1.669	2.887	7.196
iis	0.115	1.019	1.039	15	-0.262	-0.262	0.871	2.003
wcf	1.008	4.744	22.501	15	-0.199	0.888	5.124	7.280
perm	-2.077	8.436	71.165	15	-7.436	-2.275	1.716	15.949

rmexp=3

Variable	Mean	Std	Variance	N	Lower	Median	Upper	95th
isi	0.573	5.183	26.865	26	-3.516	-0.340	5.335	8.055
cwc	0.019	4.273	18.263	26	-2.983	0.189	2.306	5.335
qrks	-1.014	3.177	10.094	26	-3.835	-0.680	1.511	3.644
qrc	0.114	4.303	18.512	26	-2.368	-0.536	3.437	6.877
misf	-0.169	3.926	15.414	26	-3.098	-0.457	2.190	6.386
nccp	1.147	3.938	15.512	26	-2.139	0.839	3.738	7.488
pqc	0.601	2.935	8.616	26	-1.567	0.026	2.742	5.004
iis	-0.001	0.977	0.955	26	-0.262	-0.262	0.871	2.003
wcf	0.280	5.449	29.691	26	-5.557	0.325	3.027	8.307
perm	1.125	5.997	35.963	26	-2.457	0.381	4.257	13.511

rmexp=4

Variable	Mean	Std	Varianc	N	Lower	Median	Upper	95th
isi	-0.390	4.258	18.128	43	-4.355	-0.728	2.828	6.358
cwc	-0.376	4.014	16.110	43	-2.936	-0.561	2.306	6.332
qrks	-0.147	3.600	12.961	43	-2.697	0.391	2.559	4.655
qrc	-0.844	3.507	12.299	43	-3.536	-1.044	2.241	4.629
misf	-0.521	3.576	12.785	43	-3.151	0.099	2.196	4.301
nccp	-0.808	3.403	11.583	43	-4.038	-0.240	1.747	4.610
pqc	-1.169	4.322	18.683	43	-2.771	-0.415	1.702	3.946
iis	-0.051	0.900	0.810	43	-0.262	-0.262	0.871	0.871
wcf	-0.979	5.054	25.546	43	-5.557	-0.199	2.999	6.210
perm	0.481	6.074	36.894	43	-3.186	1.637	4.257	10.396

rmexp=5

Variabl	Mean	Std	Variance	N	Lower	Median	Upper	95th
isi	0.116	5.349	28.608	33	-3.501	1.002	4.571	8.111
cwc	0.264	4.366	19.058	33	-1.830	0.202	2.306	7.710
qrks	0.844	3.840	14.746	33	-1.873	1.476	3.644	5.867
qrc	0.467	4.160	17.304	33	-2.239	1.060	3.437	6.850
misf	0.933	4.114	16.928	33	-0.981	1.099	4.301	7.418
nccp	-0.194	3.981	15.851	33	-2.390	-0.197	3.602	6.466
pqc	-0.160	4.700	22.091	33	-2.625	0.564	2.887	6.059
iis	-0.022	1.159	1.344	33	-0.262	-0.262	0.871	2.003
wcf	0.171	4.928	24.290	33	-4.438	-0.199	4.038	9.383
perm	-1.115	8.478	71.868	33	-4.560	0.601	4.257	8.087

Table 9-1 Descriptive statistics by RM experience groups

1-Less than 1 year

2-1 to less 3 years

3-3 to less than 5 years

4-5 to less than 10 years

5-More than 10 years

rmarea=1

Variable	Mean	Std	Variance	N	Lower	Median	Upper	95th
isi	0.232	5.098	25.989	37	-3.355	0.103	3.707	8.188
cwc	-0.083	4.389	19.267	37	-2.584	0.080	3.061	5.335
qrks	-0.626	3.619	13.100	37	-2.973	-0.619	2.517	4.772
qrc	-0.385	3.763	14.161	37	-2.478	0.006	1.191	6.877
misf	-0.229	4.164	17.337	37	-3.060	1.013	2.196	6.386
nccp	-0.325	4.160	17.301	37	-3.153	-1.112	1.702	7.488
pqc	-0.180	4.048	16.388	37	-2.458	0.531	1.702	7.117
iis	0.044	0.986	0.973	37	-0.262	-0.262	0.871	2.003
wcf	-0.095	4.947	24.473	37	-1.301	-0.199	1.947	8.307
perm	0.828	6.305	39.750	37	-2.457	0.614	4.257	15.949

rmarea=2

Variable	Mean	Std	Varianc	N	Lower	Median	Upper	95th
isi	0.195	5.676	32.213	11	-4.355	1.002	4.603	6.533
cwc	-0.233	4.203	17.664	11	-3.214	0.128	2.261	6.587
qrks	-0.734	4.094	16.761	11	-2.832	0.391	2.514	4.737
qrc	-0.156	3.520	12.393	11	-3.536	1.070	2.265	4.629
misf	0.169	5.556	30.870	11	-5.177	2.125	4.392	5.392
nccp	-0.931	4.461	19.899	11	-3.153	-1.253	3.709	4.752
pqc	0.113	4.112	16.912	11	-2.659	1.702	2.742	3.946
iis	-0.159	0.794	0.630	11	-0.262	-0.262	0.871	0.871
wcf	0.472	5.896	34.764	11	-5.557	2.996	5.130	7.255
perm	-4.595	9.377	87.921	11	-7.436	-0.720	0.154	3.097

rmarea=3

Variable	Mean	Std	Variance	N	Lower	Median	Upper	95th
isi	0.270	4.571	20.890	47	-3.404	0.026	3.690	8.111
cwc	0.384	4.398	19.342	47	-1.830	0.445	2.306	8.510
qrks	0.628	3.673	13.491	47	-1.694	1.476	3.644	5.864
qrc	0.492	4.249	18.057	47	-2.361	1.060	3.437	6.850
misf	0.504	3.910	15.286	47	-0.981	1.051	3.210	6.380
nccp	0.142	4.144	17.174	47	-2.223	0.738	2.760	6.466
pqc	0.151	4.301	18.502	47	-1.713	1.604	2.887	6.059
iis	0.027	1.120	1.253	47	-1.395	-0.262	0.871	2.003
wcf	0.352	5.238	27.434	47	-4.508	0.849	4.106	7.280
perm	0.516	8.209	67.395	47	-3.842	3.038	4.257	13.526

rmarea=4

Variable	Mean	Std	Varianc	N	Lower	Median	Upper	95th
isi	-0.756	.	.	1	-0.756	-0.756	-0.756	-0.756
cwc	-4.968	.	.	1	-4.968	-4.968	-4.968	-4.968
qrks	1.559	.	.	1	1.559	1.559	1.559	1.559
qrc	4.629	.	.	1	4.629	4.629	4.629	4.629
misf	-3.098	.	.	1	-3.098	-3.098	-3.098	-3.098
nccp	0.861	.	.	1	0.861	0.861	0.861	0.861
pqc	3.979	.	.	1	3.979	3.979	3.979	3.979
iis	-0.262	.	.	1	-0.262	-0.262	-0.262	-0.262
wcf	-2.303	.	.	1	-2.303	-2.303	-2.303	-2.303
perm	0.609	.	.	1	0.609	0.609	0.609	0.609

rmarea=5

Variable	Mean	Std	Variance	N	Lower	Median	Upper	95th
isi	-2.832	5.122	26.235	3	-7.021	-4.355	2.878	2.878
cwc	-0.880	1.826	3.333	3	-2.983	0.047	0.297	0.297
qrks	-2.804	4.930	24.301	3	-7.137	-3.835	2.559	2.559
qrc	-1.147	5.299	28.078	3	-5.805	-2.253	4.618	4.618
misf	-3.506	3.203	10.258	3	-6.262	-4.263	0.008	0.008
nccp	-1.123	2.570	6.607	3	-4.038	-0.148	0.817	0.817
pqc	-1.541	4.309	18.567	3	-5.876	-1.488	2.742	2.742
iis	0.115	0.654	0.428	3	-0.262	-0.262	0.871	0.871
wcf	-2.684	4.304	18.525	3	-7.654	-0.199	-0.199	-0.199
perm	-2.918	5.209	27.132	3	-5.970	-5.880	3.097	3.097

rmarea=6

Variable	Mean	Std	Varianc	N	Lower	Median	Upper	95th
isi	-1.972	5.347	28.594	6	-4.355	-2.570	1.877	5.496
cwc	-2.175	4.123	16.999	6	-4.033	-0.957	1.199	1.199
qrks	-0.448	2.483	6.165	6	-2.797	-0.114	1.566	2.562
qrc	-1.937	3.116	9.710	6	-3.441	-1.122	-1.068	2.241
misf	-1.506	4.791	22.958	6	-2.060	-0.428	2.125	2.222
nccp	-0.682	3.095	9.579	6	-4.008	-0.636	1.747	3.602
pqc	0.067	2.039	4.159	6	-1.567	0.060	1.768	2.742
iis	0.115	0.925	0.855	6	-0.262	0.304	0.871	0.871
wcf	-1.456	3.727	13.888	6	-3.429	-0.738	0.852	2.999
perm	3.455	3.445	11.866	6	0.427	3.657	5.734	7.907

rmarea=7

Variabl	Mean	Std	Variance	N	Lower	Median	Upper	95th
isi	-0.147	4.767	22.722	16	-3.936	1.431	3.201	7.309
cwc	0.516	3.870	14.974	16	-1.592	0.623	2.816	7.866
qrks	0.705	3.713	13.790	16	-1.770	0.971	2.623	6.950
qrc	0.203	4.371	19.106	16	-2.309	0.001	3.437	9.241
misf	0.347	3.622	13.120	16	-2.033	0.118	4.301	4.301
nccp	1.388	3.428	11.752	16	-2.075	2.256	3.685	6.743
pqc	-0.090	4.849	23.509	16	-3.284	1.133	2.815	8.254
iis	-0.121	1.003	1.005	16	-1.395	-0.262	0.871	0.871
wcf	0.054	5.176	26.793	16	-2.858	-0.199	4.575	7.255
perm	-1.056	4.123	16.998	16	-3.494	-0.642	2.367	4.561

Table 9-2 Descriptive statistics by RM area groups

1-Market risk

2-Operational risk

3-Credit risk

4-Currency risk

5-Legal/regulatory risk

6-Capital risk

7-Other

rmprocess=1

Variable	Mean	Std	Variance	N	Lower	Median	Upper	95th
isi	-1.547	4.103	16.833	17	-4.355	-2.393	1.881	4.603
cwc	-2.235	4.403	19.391	17	-2.997	-1.866	0.297	4.300
qrks	-2.563	3.693	13.638	17	-5.007	-2.973	0.466	6.950
qrc	-2.001	3.552	12.615	17	-4.616	-2.239	0.006	4.618
misf	-2.107	4.531	20.531	17	-6.262	-1.018	2.125	4.301
nccp	-2.112	4.226	17.861	17	-5.170	-2.390	0.817	6.743
pqc	-2.685	4.941	24.413	17	-2.771	-2.458	0.564	4.939
iis	-0.595	0.777	0.604	17	-1.395	-0.262	-0.262	0.871
wcf	-1.777	5.266	27.726	17	-5.557	-0.199	0.849	5.165
perm	-2.226	8.925	79.659	17	-5.880	0.393	3.097	9.176

rmprocess=2

Variable	Mean	Std	Varianc	N	Lower	Median	Upper	95th
isi	4.149	5.712	32.623	2	0.110	4.149	8.188	8.188
cwc	2.761	0.644	0.415	2	2.306	2.761	3.217	3.217
qrks	0.927	3.843	14.772	2	-1.791	0.927	3.644	3.644
qrc	0.533	0.746	0.556	2	0.006	0.533	1.060	1.060
misf	-0.444	0.692	0.478	2	-0.933	-0.444	0.045	0.045
nccp	2.238	3.381	11.433	2	-0.153	2.238	4.629	4.629
pqc	1.189	2.401	5.767	2	-0.509	1.189	2.887	2.887
iis	0.304	0.801	0.642	2	-0.262	0.304	0.871	0.871
wcf	2.474	3.747	14.042	2	-0.175	2.474	5.124	5.124
perm	-2.236	2.142	4.587	2	-3.751	-2.236	-0.722	-0.722

rmprocess=3

Variable	Mean	Std	Variance	N	Lower	Median	Upper	95th
isi	6.358	.	.	1	6.358	6.358	6.358	6.358
cwc	-5.235	.	.	1	-5.235	-5.235	-5.235	-5.235
qrks	-2.739	.	.	1	-2.739	-2.739	-2.739	-2.739
qrc	1.191	.	.	1	1.191	1.191	1.191	1.191
misf	1.099	.	.	1	1.099	1.099	1.099	1.099
nccp	-0.197	.	.	1	-0.197	-0.197	-0.197	-0.197
pqc	-2.625	.	.	1	-2.625	-2.625	-2.625	-2.625
iis	-0.262	.	.	1	-0.262	-0.262	-0.262	-0.262
wcf	-0.234	.	.	1	-0.234	-0.234	-0.234	-0.234
perm	-6.217	.	.	1	-6.217	-6.217	-6.217	-6.217

rmprocess=4

Variable	Mean	Std	Varianc	N	Lower	Median	Upper	95th
isi	-0.397	5.470	29.918	47	-4.355	-0.743	4.538	8.157
cwc	-0.895	3.868	14.959	47	-3.994	0.047	2.064	4.652
qrks	-0.534	3.375	11.390	47	-2.787	-0.527	2.552	3.686
qrc	-0.139	3.911	15.295	47	-2.368	-1.068	3.319	6.874
misf	-0.631	4.140	17.143	47	-4.183	0.045	2.222	4.301
nccp	-0.606	4.168	17.369	47	-4.161	-0.197	1.752	5.765
pqc	0.090	3.728	13.895	47	-1.585	0.564	1.768	6.156
iis	-0.142	1.114	1.240	47	-1.395	-0.262	0.871	0.871
wcf	-0.034	4.517	20.401	47	-4.481	0.849	2.912	7.255
perm	-0.073	6.827	46.609	47	-4.515	1.634	4.257	9.367

rmprocess=5

Variable	Mean	Std	Variance	N	Lower	Median	Upper	95th
isi	1.597	4.052	16.418	3	-2.603	1.913	5.482	5.482
cwc	2.871	6.435	41.413	3	-4.432	5.335	7.710	7.710
qrks	1.793	4.539	20.605	3	-1.873	0.381	6.870	6.870
qrc	2.285	4.610	21.249	3	-2.368	2.373	6.850	6.850
misf	2.530	3.692	13.633	3	-0.981	2.190	6.380	6.380
nccp	3.274	4.828	23.312	3	-2.281	5.638	6.466	6.466
pqc	0.183	7.727	59.707	3	-7.146	-0.560	8.254	8.254
iis	0.871	1.133	1.283	3	-0.262	0.871	2.003	2.003
wcf	5.821	5.366	28.791	3	0.849	5.105	11.509	11.509
perm	-3.090	4.022	16.177	3	-7.436	-2.337	0.502	0.502

rmprocess=6

Variable	Mean	Std	Varianc	N	Lower	Median	Upper	95th
isi	0.515	4.668	21.794	29	-3.404	0.209	4.669	7.234
cwc	1.784	4.537	20.583	29	-0.833	1.309	4.315	8.716
qrks	1.043	3.769	14.208	29	-0.619	1.514	3.644	5.733
qrc	0.457	4.560	20.792	29	-2.361	0.116	2.501	9.241
misf	1.050	4.096	16.780	29	-0.981	1.158	4.301	7.418
nccp	1.283	4.033	16.261	29	-0.989	1.702	3.646	8.564
pqc	0.929	4.189	17.550	29	-0.494	1.669	2.742	8.254
iis	0.285	0.889	0.790	29	-0.262	0.871	0.871	0.871
wcf	0.788	5.913	34.960	29	-4.453	1.978	5.124	9.383
perm	0.591	7.450	55.504	29	-3.803	0.601	4.257	15.949

rmprocess=7

Variable	Mean	Std	Variance	N	Lower	Median	Upper	95th
isi	1.304	4.116	16.941	12	-1.236	2.674	4.119	6.533
cwc	1.567	3.188	10.161	12	-1.017	2.284	3.419	6.587
qrks	1.508	3.326	11.061	12	-0.616	2.013	3.689	5.864
qrc	0.862	3.839	14.738	12	-0.598	1.124	4.565	5.941
misf	0.541	3.631	13.181	12	-1.480	0.618	3.288	5.392
nccp	0.611	2.370	5.615	12	-0.740	-0.132	2.256	4.752
pqc	1.712	2.163	4.679	12	1.124	2.222	2.906	3.946
iis	0.304	0.764	0.583	12	-0.262	0.871	0.871	0.871
wcf	-0.305	4.085	16.691	12	-4.495	0.311	2.464	6.179
perm	1.965	5.710	32.607	12	-0.668	1.012	3.647	13.511

rmprocess=8

Variable	Mean	Std	Varianc	N	Lower	Median	Upper	95th
isi	3.114	2.065	4.263	3	1.843	2.002	5.496	5.496
cwc	0.942	2.715	7.374	3	-1.231	0.071	3.986	3.986
qrks	0.685	2.485	6.176	3	-0.754	-0.746	3.555	3.555
qrc	0.789	3.702	13.706	3	-3.441	2.373	3.437	3.437
misf	1.813	2.225	4.951	3	0.014	1.125	4.301	4.301
nccp	3.044	2.938	8.634	3	-0.148	3.641	5.638	5.638
pqc	1.658	1.877	3.522	3	-0.509	2.742	2.742	2.742
iis	0.493	0.654	0.428	3	-0.262	0.871	0.871	0.871
wcf	2.276	4.441	19.721	3	-1.276	0.849	7.255	7.255
perm	6.416	9.211	84.852	3	-2.436	5.734	15.949	15.949

rmprocess=9

Variabl	Mean	Std	Variance	N	Lower	Median	Upper	95th
isi	-2.057	3.549	12.598	7	-4.355	-2.528	1.883	2.709
cwc	-0.319	2.713	7.360	7	-1.977	0.047	2.306	3.172
qrks	1.964	3.136	9.835	7	0.391	2.604	3.644	5.867
qrc	0.782	3.944	15.558	7	-3.536	2.265	3.437	4.629
misf	2.186	3.673	13.489	7	-0.981	3.210	4.392	7.466
nccp	-0.484	1.130	1.277	7	-1.371	-0.245	0.861	0.861
pqc	-1.623	4.504	20.287	7	-7.210	-0.494	1.702	3.979
iis	0.062	1.077	1.161	7	-0.262	-0.262	0.871	2.003
wcf	-2.342	5.015	25.154	7	-5.557	-0.259	0.858	3.029
perm	0.181	6.886	47.423	7	-1.970	0.609	4.257	8.087

Table 9-3 Descriptive statistics by RM process groups

1-Risk identification

2-Risk hedging

3-Risk transfer

4-Risk quantification

5-Risk classification

6-Risk evaluation

7-Risk mitigation

8-Risk mapping

9-Other

timeposit=1

Variable	Mean	Std	Variance	N	Lower	Median	Upper	95th
isi	-0.320	4.343	18.864	16	-3.453	-1.618	2.343	8.111
cwc	-0.208	4.056	16.453	16	-3.990	-0.381	2.739	7.866
qrks	0.952	3.021	9.124	16	-1.183	1.540	3.074	4.647
qrc	0.483	3.839	14.741	16	-1.718	0.533	2.319	9.241
misf	0.592	3.350	11.222	16	-1.024	1.104	3.197	4.361
nccp	-0.916	3.190	10.175	16	-3.593	-0.172	1.304	3.641
pqc	1.343	3.861	14.904	16	0.019	1.702	3.344	8.254
iis	-0.121	0.814	0.663	16	-0.262	-0.262	0.871	0.871
wcf	-0.276	3.294	10.852	16	-2.857	-0.199	0.869	5.124
perm	2.127	8.680	75.344	16	1.117	2.951	5.701	15.949

timeposit=2

Variable	Mean	Std	Varianc	N	Lower	Median	Upper	95th
isi	-0.734	5.051	25.510	49	-4.355	-0.826	2.709	8.055
cwc	-0.974	4.305	18.529	49	-3.994	-0.940	2.211	5.335
qrks	-0.530	3.882	15.067	49	-3.790	-0.614	2.604	5.730
qrc	-0.826	3.742	14.003	49	-2.368	-1.068	2.255	4.629
misf	-0.945	4.177	17.445	49	-3.086	-0.889	2.136	4.301
nccp	-0.502	4.329	18.739	49	-4.008	-0.240	3.646	5.765
pqc	-1.348	4.630	21.437	49	-4.431	-0.494	1.768	5.004
iis	-0.170	1.004	1.007	49	-0.262	-0.262	0.871	0.871
wcf	-0.951	4.909	24.098	49	-5.557	-0.199	2.009	5.165
perm	-1.129	6.901	47.625	49	-4.552	-0.613	3.038	9.367

timeposit=3

Variable	Mean	Std	Variance	N	Lower	Median	Upper	95th
isi	0.222	5.090	25.911	30	-3.454	-0.365	3.693	8.157
cwc	0.482	4.551	20.712	30	-2.983	1.199	3.061	8.510
qrks	-0.504	3.795	14.401	30	-3.904	-0.115	2.559	5.733
qrc	0.941	4.227	17.870	30	-2.368	1.716	4.618	6.877
misf	0.352	4.088	16.716	30	-3.098	1.045	3.216	7.466
nccp	0.521	3.470	12.039	30	-2.223	0.738	1.752	7.488
pqc	0.635	3.129	9.793	30	-1.567	0.587	2.742	6.156
iis	0.040	1.028	1.056	30	-0.262	-0.262	0.871	2.003
wcf	0.182	5.524	30.517	30	-5.557	0.849	2.999	7.255
perm	0.547	8.230	67.738	30	-2.203	1.187	4.257	13.511

timeposit=4

Variable	Mean	Std	Varianc	N	Lower	Median	Upper	95th
isi	1.862	3.619	13.095	19	-0.730	1.928	4.603	7.309
cwc	1.434	3.576	12.787	19	-1.231	1.029	3.326	8.716
qrks	1.152	3.291	10.832	19	-0.754	2.517	2.559	6.870
qrc	0.125	3.998	15.981	19	-3.552	0.113	3.437	6.850
misf	0.848	4.397	19.332	19	-3.060	2.125	3.275	6.386
nccp	0.719	4.212	17.745	19	-2.139	0.866	4.624	6.466
pqc	0.784	4.036	16.287	19	-2.589	1.702	3.879	8.254
iis	0.334	1.092	1.193	19	-0.262	0.871	0.871	2.003
wcf	1.407	5.781	33.415	19	-1.301	0.849	6.120	11.509
perm	0.496	5.217	27.217	19	-2.436	0.585	3.097	13.526

timeposit=5

Variabl	Mean	Std	Variance	N	Lower	Median	Upper	95th
isi	-0.138	6.042	36.506	7	-6.948	1.002	6.358	7.234
cwc	1.333	3.441	11.843	7	-1.075	0.128	2.306	8.594
qrks	0.570	3.744	14.018	7	-0.619	0.391	3.644	5.775
qrc	0.306	5.123	26.247	7	-3.536	-0.132	4.629	9.241
misf	1.452	4.553	20.730	7	-0.981	2.275	4.392	7.418
nccp	1.422	4.532	20.536	7	-1.371	0.738	5.638	8.564
pqc	1.520	3.128	9.786	7	-0.430	1.507	5.004	6.059
iis	0.385	0.891	0.794	7	-0.262	0.871	0.871	0.871
wcf	2.688	4.217	17.780	7	-0.219	3.003	6.203	9.383
perm	-0.650	4.874	23.752	7	-4.515	-1.970	4.257	4.257

Table 9-4 Descriptive Statistics by time in the position groups

1-Less than 1 year

2-1 to less 3 years

3-3 to less than 5 years

4-5 to less than 10 years

5-More than 10 years

9.3. Demographic Distributions

Categories Number	N	rmarea							rmexp					rmprocess									timeposit				
		1	2	3	4	5	6	7	1	2	3	4	5	1	2	3	4	5	6	7	8	9	1	2	3	4	5
		N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
rmarea																											
Credit risk	47	0	0	47	0	0	0	0	1	9	8	15	14	3	1	0	19	3	14	4	1	2	7	19	11	5	5
Market risk	37	37	0	0	0	0	0	0	1	4	8	13	11	6	1	1	19	0	9	0	0	1	4	14	8	10	1
Operational risk	11	0	11	0	0	0	0	0	0	2	3	4	2	4	0	0	0	0	2	4	0	1	1	4	3	2	1
Capital risk	6	0	0	0	0	0	6	0	0	0	2	2	2	0	0	0	4	0	1	0	1	0	2	3	1	0	0
Legal/regulatory risk	3	0	0	0	0	3	0	0	0	0	1	2	0	2	0	0	1	0	0	0	0	0	0	0	3	0	0
Currency risk	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0
Other	16	0	0	0	0	0	0	16	2	0	3	7	4	2	0	0	4	0	3	4	1	2	2	9	3	2	0
rmexp																											
Less than 1 year	4	1	0	1	0	0	0	2	4	0	0	0	0	0	0	0	1	0	1	0	2	0	3	0	0	1	0
1 to less than 3 years	15	4	2	9	0	0	0	0	0	15	0	0	0	3	2	0	5	0	5	0	0	0	2	13	0	0	0
3 to less than 5 years	26	8	3	8	1	1	2	3	0	0	26	0	0	3	0	0	12	1	3	5	1	1	2	6	16	2	0
5 to less than 10 years	43	13	4	15	0	2	2	7	0	0	0	43	0	6	0	0	21	0	10	3	0	3	4	16	9	11	3
More than 10 years	33	11	2	14	0	0	2	4	0	0	0	0	33	5	0	1	8	2	10	4	0	3	5	14	5	5	4
rmprocess																											
Risk quantification	47	19	0	19	0	1	4	4	1	5	12	21	8	0	0	0	47	0	0	0	0	0	4	19	12	10	2
Risk evaluation	29	9	2	14	0	0	1	3	1	5	3	10	10	0	0	0	0	0	29	0	0	0	5	11	5	5	3
Risk identification	17	6	4	3	0	2	0	2	0	3	3	6	5	17	0	0	0	0	0	0	0	0	2	7	7	1	0
Risk mitigation	12	0	4	4	0	0	0	4	0	0	5	3	4	0	0	0	0	0	0	12	0	0	1	5	4	1	1
Risk classification	3	0	0	3	0	0	0	0	0	0	1	0	2	0	0	0	0	3	0	0	0	0	0	2	0	1	0
Risk mapping	3	0	0	1	0	0	1	1	2	0	1	0	0	0	0	0	0	0	0	0	3	0	2	0	0	1	0
Risk hedging	2	1	0	1	0	0	0	0	0	2	0	0	0	0	2	0	0	0	0	0	0	0	0	2	0	0	0
Risk transfer	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0
Other	7	1	1	2	1	0	0	2	0	0	1	3	3	0	0	0	0	0	0	0	0	7	1	3	2	0	1
timeposit																											
Less than 1 year	16	4	1	7	0	0	2	2	3	2	2	4	5	2	0	1	4	0	5	1	2	1	16	0	0	0	0
1 to less than 3 years	49	14	4	19	0	0	3	9	0	13	6	16	14	7	2	0	19	2	11	5	0	3	0	49	0	0	0
3 to less than 5 years	30	8	3	11	1	3	1	3	0	0	16	9	5	7	0	0	12	0	5	4	0	2	0	0	30	0	0
5 to less than 10 years	19	10	2	5	0	0	0	2	1	0	2	11	5	1	0	0	10	1	5	1	1	0	0	0	0	19	0
More than 10 years	7	1	1	5	0	0	0	0	0	0	0	3	4	0	0	0	2	0	3	1	0	1	0	0	0	0	7

rmarea		rmexp and timeposit		rmprocess	
1	Market risk	1	Less than 1 year	1	Risk identification
2	Operational risk	2	1 to less than 3 years	2	Risk hedging
3	Credit risk	3	3 to less than 5 years	3	Risk transfer
4	Currency risk	4	5 to less than 10 years	4	Risk quantification
5	Legal/regulatory risk	5	More than 10 years	5	Risk classification
6	Capital risk			6	Risk evaluation
7	Other			7	Risk mitigation
				8	Risk mapping
				9	Other

Table 9-5 Demographic distributions of the data

Categories Number	%	N	rmarea							rmexp					rmprocess									timeposit				
			1 %	2 %	3 %	4 %	5 %	6 %	7 %	1 %	2 %	3 %	4 %	5 %	1 %	2 %	3 %	4 %	5 %	6 %	7 %	8 %	9 %	1 %	2 %	3 %	4 %	5 %
rmarea																												
Credit risk	39%	47								2	19	17	32	30	6	2	0	40	6	30	9	2	4	15	40	23	11	11
Market risk	31%	37								3	11	22	35	30	16	3	3	51	0	24	0	0	3	11	38	22	27	3
Operational risk	9%	11								0	18	27	36	18	36	0	0	0	0	18	36	0	9	9.1	36	27	18	9
Capital risk	5%	6								0	0	33	33	33	0	0	0	67	0	17	0	17	0	33	50	17	0	0
Legal/regulatory risk	2%	3								0	0	33	67	0	67	0	0	33	0	0	0	0	0	0	0	100	0	0
Currency risk	1%	1								0	0	100	0	0	0	0	0	0	0	0	0	0	100	0	0	100	0	0
Other	13%	16								13	0	19	44	25	13	0	0	25	0	19	25	6	13	13	56	19	13	0
rmexp																												
Less than 1 year	3%	4	25	0	25	0	0	0	50						0	0	0	25	0	25	0	50	0	75	0	0	25	0
1 to less than 3 years	12%	15	27	13	60	0	0	0	0						20	13	0	33	0	33	0	0	0	13	87	0	0	0
3 to less than 5 years	21%	26	31	12	31	4	4	8	12						12	0	0	46	4	12	19	4	4	8	23	62	8	0
5 to less than 10 years	36%	43	30	9	35	0	5	5	16						14	0	0	49	0	23	7	0	7	9	37	21	26	7
More than 10 years	27%	33	33	6	42	0	0	6	12						15	0	3	24	6	30	12	0	9	15	42	15	15	12
rmprocess																												
Risk quantification	39%	47	40	0	40	0	2	9	9	2	11	26	45	17										9	40	26	21	4
Risk evaluation	24%	29	31	7	48	0	0	3	10	3	17	10	34	34										17	38	17	17	10
Risk identification	14%	17	35	24	18	0	12	0	12	0	18	18	35	29										12	41	41	6	0
Risk mitigation	10%	12	0	33	33	0	0	0	33	0	0	42	25	33										8	42	33	8	8
Risk classification	2%	3	0	0	100	0	0	0	0	0	0	33	0	67										0	67	0	33	0
Risk mapping	2%	3	0	0	33	0	0	33	33	67	0	33	0	0										67	0	0	33	0
Risk hedging	2%	2	50	0	50	0	0	0	0	0	100	0	0	0										0	100	0	0	0
Risk transfer	1%	1	100	0	0	0	0	0	0	0	0	0	0	100										100	0	0	0	0
Other	6%	7	14	14	29	14	0	0	29	0	0	14	43	43										14	43	29	0	14
timeposit																												
Less than 1 year	13%	16	25	6	44	0	0	13	13	19	13	13	25	31	13	0	6	25	0	31	6	13	6					
1 to less than 3 years	40%	49	29	8	39	0	0	6	18	0	27	12	33	29	14	4	0	39	4	22	10	0	6					
3 to less than 5 years	25%	30	27	10	37	3	10	3	10	0	0	53	30	17	23	0	0	40	0	17	13	0	7					
5 to less than 10 years	16%	19	53	11	26	0	0	0	11	5	0	11	58	26	5	0	0	53	5	26	5	5	0					
More than 10 years	6%	7	14	14	71	0	0	0	0	0	0	0	43	57	0	0	0	29	0	43	14	0	14					

rmarea		rmexp and timeposit		rmprocess	
1	Market risk	1	Less than 1 year	1	Risk identification
2	Operational risk	2	1 to less than 3 years	2	Risk hedging
3	Credit risk	3	3 to less than 5 years	3	Risk transfer
4	Currency risk	4	5 to less than 10 years	4	Risk quantification
5	Legal/regulatory risk	5	More than 10 years	5	Risk classification
6	Capital risk			6	Risk evaluation
7	Other			7	Risk mitigation
				8	Risk mapping
				9	Other

Table 9-6 Distribution (%) of the Categories of the demographic variables

9.4. Additional results with variable interactions

Analysis Of Parameter Estimates							
Parameter	**DF**	**Estimate**	**Standard Error**	**Wald 95% Confidence Limits**		**Chi-Square**	**Pr > ChiSq**
Intercept	1	-1.3585	0.4277	-2.1967	-0.5203	10.0900	0.0015
qrks	1	0.1958	0.0897	0.0200	0.3717	4.7600	0.0290
wcf	1	0.1208	0.0739	-0.0241	0.2657	2.6700	0.1022
pqc	1	0.1036	0.0785	-0.0502	0.2574	1.7400	0.1869
misf	1	0.2657	0.0937	0.0820	0.4495	8.0400	0.0046
isi*isi	1	0.0249	0.0113	0.0028	0.0470	4.8600	0.0274
cwc*cwc	1	0.0854	0.0246	0.0372	0.1335	12.0700	0.0005
nccp*nccp	1	-0.0067	0.0218	-0.0495	0.0361	0.0900	0.7604
iis*iis	1	0.0901	0.2697	-0.4386	0.6188	0.1100	0.7383
qrks*qrks	1	0.0753	0.0291	0.0182	0.1323	6.6800	0.0097
wcf*wcf	1	0.0028	0.0124	-0.0215	0.0272	0.0500	0.8189
pqc*pqc	1	0.0187	0.0180	-0.0165	0.0540	1.0900	0.2966
misf*misf	1	-0.0298	0.0200	-0.0689	0.0094	2.2200	0.1361
isi	1	-0.0092	0.0500	-0.1072	0.0889	0.0300	0.8545
cwc	1	0.2710	0.0845	0.1054	0.4367	10.2900	0.0013
nccp	1	0.0458	0.0846	-0.1201	0.2117	0.2900	0.5884
iis	1	0.5549	0.2838	-0.0012	1.1111	3.8200	0.0505
qrks*wcf	1	0.0425	0.0276	-0.0117	0.0966	2.3600	0.1245
qrks*pqc	1	0.0461	0.0300	-0.0127	0.1050	2.3600	0.1243
qrks*misf	1	-0.0312	0.0289	-0.0878	0.0255	1.1600	0.2813
qrks*isi	1	0.0280	0.0274	-0.0257	0.0816	1.0400	0.3072
qrks*cwc	1	-0.0789	0.0436	-0.1643	0.0066	3.2700	0.0704
qrks*nccp	1	-0.0714	0.0335	-0.1370	-0.0058	4.5600	0.0328
qrks*iis	1	-0.2584	0.1171	-0.4880	-0.0289	4.8700	0.0273
wcf*pqc	1	-0.0475	0.0201	-0.0869	-0.0081	5.5800	0.0182
wcf*misf	1	0.0082	0.0229	-0.0368	0.0531	0.1300	0.7220
wcf*isi	1	-0.0043	0.0141	-0.0319	0.0234	0.0900	0.7633
wcf*cwc	1	-0.0326	0.0252	-0.0820	0.0168	1.6700	0.1956
wcf*nccp	1	-0.0011	0.0236	-0.0474	0.0452	0.0000	0.9627
wcf*iis	1	0.0913	0.0779	-0.0615	0.2440	1.3700	0.2417
pqc*misf	1	-0.0138	0.0277	-0.0682	0.0405	0.2500	0.6184
pqc*isi	1	-0.0299	0.0195	-0.0681	0.0083	2.3600	0.1247
pqc*cwc	1	-0.0311	0.0282	-0.0863	0.0241	1.2200	0.2691
pqc*nccp	1	0.0692	0.0267	0.0169	0.1216	6.7200	0.0096
pqc*iis	1	-0.1612	0.1063	-0.3696	0.0471	2.3000	0.1294
misf*isi	1	0.0290	0.0210	-0.0122	0.0702	1.9000	0.1677
misf*cwc	1	0.0312	0.0300	-0.0276	0.0900	1.0800	0.2984
misf*nccp	1	0.0596	0.0312	-0.0015	0.1207	3.6600	0.0558
misf*iis	1	0.0346	0.1013	-0.1639	0.2331	0.1200	0.7325
isi*cwc	1	-0.0593	0.0208	-0.1001	-0.0185	8.1000	0.0044
isi*nccp	1	0.0255	0.0248	-0.0231	0.0741	1.0600	0.3041
isi*iis	1	-0.1277	0.0654	-0.2559	0.0005	3.8100	0.0509
cwc*nccp	1	-0.0657	0.0375	-0.1392	0.0077	3.0800	0.0794
cwc*iis	1	0.2639	0.1431	-0.0167	0.5444	3.4000	0.0653
nccp*iis	1	-0.0939	0.1092	-0.3080	0.1202	0.7400	0.3898
Scale	1	1.7846	0.1147	1.5733	2.0242		

Table 9-7 Regression model QRC considering interactions

9.5. Test of Convergent Validity

	qrks1	qrks2	qrks3	qrks4	qrks5
qrks1	1,00	0,24	0,53	0,40	0,19
qrks2	0,24	1,00	0,45	0,46	0,41
qrks3	0,53	0,45	1,00	0,49	0,36
qrks4	0,40	0,46	0,49	1,00	0,72
qrks5	0,19	0,41	0,36	0,72	1,00

	qrc1	qrc2	qrc3	qrc4	qrc5
qrc1	1,00	0,61	0,62	0,48	0,47
qrc2	0,61	1,00	0,47	0,55	0,55
qrc3	0,62	0,47	1,00	0,60	0,52
qrc4	0,48	0,55	0,60	1,00	0,63
qrc5	0,47	0,55	0,52	0,63	1,00

	misf1	misf2	misf3	misf4	misf5
misf1	1,00	0,80	0,62	0,46	0,54
misf2	0,80	1,00	0,67	0,48	0,58
misf3	0,62	0,67	1,00	0,56	0,56
misf4	0,46	0,48	0,56	1,00	0,75
misf5	0,54	0,58	0,56	0,75	1,00

	nccp1	nccp2	nccp3	nccp4	nccp5
nccp1	1,00	0,73	0,61	0,52	0,38
nccp2	0,73	1,00	0,62	0,56	0,46
nccp3	0,61	0,62	1,00	0,64	0,40
nccp4	0,52	0,56	0,64	1,00	0,51
nccp5	0,38	0,46	0,40	0,51	1,00

	pqc1	pqc2	pqc3	pqc4	pqc5
pqc1	1,00	0,54	0,71	0,56	0,60
pqc2	0,54	1,00	0,54	0,49	0,59
pqc3	0,71	0,54	1,00	0,69	0,68
pqc4	0,56	0,49	0,69	1,00	0,63
pqc5	0,60	0,59	0,68	0,63	1,00

	iss1	iss2	iss3	iss4	iss5	iss6
iss1	1,00	0,74	0,47	0,37	0,53	0,46
iss2	0,74	1,00	0,67	0,58	0,61	0,60
iss3	0,47	0,67	1,00	0,64	0,51	0,59
iss4	0,37	0,58	0,64	1,00	0,58	0,71
iss5	0,53	0,61	0,51	0,58	1,00	0,65
iss6	0,46	0,60	0,59	0,71	0,65	1,00
	cwc1	**cwc2**	**cwc3**	**cwc4**	**cwc5**	**cwc6**
cwc1	1,00	0,83	0,26	0,44	0,20	0,25
cwc2	0,83	1,00	0,24	0,39	0,23	0,24
cwc3	0,26	0,24	1,00	0,32	0,50	0,58
cwc4	0,44	0,39	0,32	1,00	0,41	0,32
cwc5	0,20	0,23	0,50	0,41	1,00	0,74
cwc6	0,25	0,24	0,58	0,32	0,74	1,00
	wcf1	**wcf2**	**wcf3**	**wcf4**	**wcf5**	**wcf6**
wcf1	1,00	0,62	0,55	0,60	0,65	0,62
wcf2	0,62	1,00	0,62	0,56	0,62	0,55
wcf3	0,55	0,62	1,00	0,72	0,69	0,66
wcf4	0,60	0,56	0,72	1,00	0,73	0,71
wcf5	0,65	0,62	0,69	0,73	1,00	0,79
wcf6	0,62	0,55	0,66	0,71	0,79	1,00

	perm1	perm2	perm3	perm4	perm5	perm6	perm7	perm8	perm9
perm1	1,00	0,77	0,51	0,53	0,68	0,69	0,58	0,53	0,46
perm2	0,77	1,00	0,56	0,52	0,63	0,65	0,61	0,60	0,52
perm3	0,51	0,56	1,00	0,45	0,51	0,50	0,54	0,48	0,44
perm4	0,53	0,52	0,45	1,00	0,60	0,59	0,65	0,59	0,48
perm5	0,68	0,63	0,51	0,60	1,00	0,81	0,67	0,64	0,54
perm6	0,69	0,65	0,50	0,59	0,81	1,00	0,68	0,64	0,62
perm7	0,58	0,61	0,54	0,65	0,67	0,68	1,00	0,66	0,63
perm8	0,53	0,60	0,48	0,59	0,64	0,64	0,66	1,00	0,62
perm9	0,46	0,52	0,44	0,48	0,54	0,62	0,63	0,62	1,00

Table 9-8 Correlation intra-items Convergent Validity All significant at 1%