Before and After Modeling:
Risk Knowledge Management is Required

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Abstract

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 is conceived mainly in financial terms, as, for example, in the banking sector. The banking sector has sophisticated methodologies for managing risk, such as mathematical risk modeling. However, the methodologies for analyzing risk do not explicitly include knowledge management for risk knowledge creation and risk knowledge transfer.

Banks are affected by internal and external changes with the consequent accommodation to new business models, new regulations and the competition of big players around the world. Thus, banks have different levels of risk appetite and policies in risk management. This paper takes into consideration that business models are changing and that management is looking across the organization to identify the influence of strategic planning, information systems theory, risk management and knowledge management. These disciplines can handle the risks affecting banking that arise from different areas, but only if they work together. This creates a need to view them in an integrated way.

This article sees enterprise risk management as a specific application of knowledge in order to control deviations from strategic objectives, shareholders' values and stakeholders' relationships. Before and after a modeling process it is necessary to find insights into how the application of knowledge management processes can improve the understanding of risk and the implementation of enterprise risk management. The article presents a proposed methodology to contribute to providing a guide for developing risk modeling knowledge and a reduction of knowledge silos, in order to improve the quality and quantity of solutions related to risk inquiries across the organization.

1. Introduction

The aim of this article is to design a methodology to improve the risk modeling process using knowledge management (KM) concepts and tools. The risk modeling process is considered a support structure of the decision-making process in order to pursue a strategic planning process and strategy implementation. The article identifies different perspectives of the problem of risk modeling and proposes a methodological solution through: the use of the theory in enterprise risk management (ERM) and KM using the context of a new view of organizational problems, the review of the historical episodes that created mathematical knowledge when groups shared knowledge and the analysis of the modeling process of three risk model examples.

The issues with ERM considered in this article related to the risk modeling process are: to be more efficient and effective in order to get better solutions for risk issues, to extend the experience, results and solutions to more problems, to use technology in a better way, to organize an integral risk information system and to improve the decision-making process. All these challenges are associated with work across the organization done with similar tools, different types of risk and similar modeling processes (mathematical and conceptual).

The article is organized thus: first, presenting the general theory of strategy and decision-making processes, next the KM and ERM theory and followed by the relationship identification between the two disciplines in order to define a general methodology for risk modeling based on knowledge management. The value of the methodology is in contributing to the improvement of the risk modeling process for the decision-making process in an evolving organization. Earl (2000) wrote that the evolution of the organizations is based on looking to adapt their capacities to the business in an information age. The process of transformation of the organization is the last, after passing from different levels starting in external communications to e-commerce, e-business and e-enterprise.

The concept of the transformation stage has a critical factor that is continuous learning and change under a dynamic model of workers' mindset that need higher coordination, information consolidation and strategic planning. New ways of management have emerged to deal with transformation, and many authors identify KM and ERM views as very important in competitiveness and strategy (Dickinson, 2001; Dalkir, 2005; Nonaka and Toyama, 2003), and in both disciplines the management view is holistic. The transformation affects the management basis including a view in two dimensions: horizontal or across the whole organization and vertical or functions or specific areas. The concept of two dimensions looking for a holistic view of risk problems needs to prepare management in order to use new tools, technology and methods.

The two dimensions view means a search for capacity to identify market opportunities, manage their risks and identify what the organization requires for reaching these opportunities. The search for this capacity pushes the companies to develop solutions and tools to expand covertures and diversify actions, which creates new risks to manage. Particularly, the information systems and risk modeling process have to be more efficient and effective in order to help people to make more complex decisions. The transformation and the strategy require some kind of integrity in order to develop new answers to business models and the way to manage them.

In fact, the strategy in transformation stage and the value proposition of the organization are related to: alignment of the elements of support to the business, securing of the information risks, speed in the delivery of service, reduction in the cost of service, improvement of the service quality and management of risks. Thus, the management of the organizations is looking to create value in the internal and external client using accumulation of knowledge, using experience to improve IT and business processes, aligning business strategies and technology, establishing a series of relations between the administration of the organization and the different groups of interest, organizing structures that comply with the strategic development of the organization and providing transparency in the information in terms of conditions, decisions and actions.

Additionally, decisions require models to reduce uncertainty that is unknowable and to move to a risk scenario that is knowable in the transformation of the organizations, as Buchanan and O'Connell (2006) expressed "companies must be able to calculate and manage the attendant risks." The decision-making process involves resources and people. In particular, computers, information and minds are connected in order to develop solutions to decision problems. Creation of knowledge through operations research, decision analysis tools, data structures and methods of sharing knowledge and collaboration is part of the support systems. In some cases, the machines are designed with means to make some decisions and at the same time some systems are designed to make decisions based on algorithms, rules and predefined models. The limitation of the machines, as Turing (1950) presented in the sense of capacity of thinking, identifies that the human knowledge used in the creation of models can contribute to the reduction of uncertainty and with the machines' support to develop the capacity for better modeling process and risk management. In particular, the risk modeling process requires risk knowledge and management of the structure to coordinate the knowledge required in the modeling process in a decision-making process under uncertainty.

The transit from uncertainty to risk understanding is supported by models. A model (Klugman et al., 1998) in the risk management world is defined as "a simplified mathematical description which is constructed based on the knowledge and the experience of the actuary combined with data from the past." The description of the modeling process includes the steps of modeling: first selection, model calibration, fit validation, new model selection, comparison of models and identification of application for the future. Thus, in order to understand the knowledge mobilization to risk modeling, the next section includes the conceptual bases for understanding modeling under the concept of risk knowledge management.

2. Risk Knowledge Management (RIKMAN)

This section introduces the concepts of knowledge management, risk, risk management and ERM to build the concept of RIKMAN. RIKMAN is used in this article as the organization for using systematically risk management expertise in the enterprise.

KM includes the concept of knowledge creation presented by Nonaka and Takeuchi (1995), who concentrate on the interaction between two knowledge types, tacit and explicit knowledge. Tacit knowledge is represented by experience, beliefs and technical skills accumulated in the people's minds. Explicit knowledge is the knowledge expressed in documents, data and other codified forms.

The interactions and movements from tacit and explicit knowledge to tacit and explicit knowledge on the individual and organizational level generate the knowledge creation in an organization. The dynamic is expressed through the following processes (Table 1):

Table 1
Dynamic Stages of Explicit and Tacit Knowledge

FROM/TO	Explicit	Tacit
Explicit	Combination	Internalization
Tacit	Externalization	Socialization

Additionally, Davenport and Prusak (1998) identified in their definition of knowledge the following components: 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 knowledge and the way to describe and apply knowledge. Fourth, organization is the place where the knowledge is offered and processed.

Moreover, Alavi and Leidner (2001) complemented the previous definition components describing the subject of interest for KM and summarizing knowledge as "a process of applying expertise." Burnstein et al. (2002) presented KM as "a management technique to maximize the co-ordination and organization of knowledge" and Alavi and Leidner (2001) identified the KM processes: creation, storage and retrieval, transfer and application of knowledge. These processes are looking for creating value from intangible assets: human capital, structural capital, intellectual capital, customer or relationship capital. To achieve the goal of creating value the KM processes are described as follows:

- Knowledge creation: Generation and discovery of new knowledge. Acquisition, synthesis, fusion and adaptation of existing knowledge.

- Knowledge storage and retrieval: Codification, organization and representation of knowledge. It includes the activities of preserve, maintain and index knowledge.

- Knowledge transfer: Knowledge dissemination and distribution within a community using different channels. Individuals, groups, organizations and inter-organizations.

- Knowledge application: Here is where the competitive advantage is. This is the clear relationship to business processes.

Furthermore, the information systems have influence in the KM processes development as means to provide analysis and solutions to the decision-making process and as a step in transformation. The reason is that 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 (Steven, 1999). Organizations have followed two approaches (Laudon and Laudon, 2004) to design information systems: the technical and the behavioral, which include social sciences, operations research and computing. Both approaches can consider as main phases for building a system the following: initiation, development, implementation, operation and maintenance (Steven, 1999).

The design purpose of an information system is making decisions and taking actions. From the results of these decisions it is possible to accumulate knowledge in order to use it later. However, the literature currently is full of new concepts that are defined enterprise-wide as an evolution of the search for enterprise-wide answers, with principles of integration and consolidation, search of 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—for instance: Enterprise Resources Planning (Stevens, 2003); Enterprise Risk Management (Dickinson, 2001); Enterprise Architecture (Zachmann, 1996); and Enterprise Content Management (Smith and McKeens, 2003). However, systems are more for operation and less for interpretation, work flow and collaboration.

From this evolution of information systems and enterprise integration systems appears the question as to whether a Knowledge Management System (KMS) can exist at the same time as the risk management information system in a financial organization. To address this question, it is important to understand that the KM processes implementation needs to go through the following five stages: identification of knowledge areas, knowledge mapping or knowledge identification, championship and organizational support, performance evaluation and implementation (Lehaney et al., 2004).

These stages have to be supported by a KMS, which, according to Alavi and Leidner (2001), is composed of two subsystems: technology and organization. The KMS is an information system that can help in many tasks of knowledge recovering, networking and accessing knowledge. However, 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 it has been expressed by Edwards et al. (2003), the KMS technology and people are important factors for the KMS design and implementation. Finally, Lehaney et al. (2004) summarized that the KMS is the ensemble of three subsystems:

- People interactions, KM and knowledge acquisition are subject to perceptions and agreement.
- Technology acting as support and the way to enable the KM function.
- Organizational structures.

Now, after introducing some of the KM concepts and looking for relationships between KM and ERM, the risk management concepts are presented. Risk is for this article "the uncertainty about the world and uncertainty expressed by probabilities related to the observable quantities (Performance Measures)" (Aven, 2003). This means studying the variance of the expected results conditioned to previous knowledge. Risk management (RM) should not be confused with risk measurement. The reason is that risk measurement "entails the quantification of risk exposures" and risk management comprises "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).

The risk modelling process is a mathematical and conceptual process. The mathematical model (Caldwell and Ram, 1999) starts from a problem and variables definition, introducing observations, data, description of the relationships among variables (generally equations and basic data models), assumptions (experience-knowledge) and with people's knowledge produces solutions-outcomes (required knowledge for solving the model) that can be used for the specific problem solution or with additional knowledge applicable to several problems. Within the process, a loop of formulation and test for different model options is always present and at the same time the question is whether there are mathematical solutions to apply.

Thus, risk modeling is part of the risk measurement process providing support to the role of RM in the strategic management development (Meulbroek, 2002; Sharman, 2002; Liebenberg and Hoyt, 2003; Banham, 2004). Risk modeling keeps the importance of RM in having the capacity of creating value from an integral view of risk (Brown, 2001; Froot et al., 1994; Banham, 2004) in order to develop a competitive advantage (Galloway and Funston, 2000).

However, the competitive advantage of the organization can be limited because of potential losses. The financial losses according to Simmons (1999) have causes such as expansion, cultural pressures, reduced controls, communication of business values, learning systems and concentration on information, some of them that belong to KM processes. These causes are influenced by an increment of the business complexity, transaction creation, lack of control, information management and the use of cost as the only important factor to manage. The business complexity and the cost of knowledge show the need for providing more meaning to the information and better KM (Sutcliffe and Weber, 2003) in order to build actionable answers to risk threats. Risk modeling knowledge can provide meaning to information, create knowledge and support actions but it needs to find means for a better use of outcomes and their understanding.

Given the business environment pressures, organizations have transformed a reactive RM into a strategic discipline, which adds value through the learning, risk analysis and solutions as part of the day-to-day business (Meulbroek, 2002; Sharman, 2002; Liebenberg and Hoyt, 2003; Banham, 2004). However, the exposure to more risks and the losses in previous years introduced doubts about the RM practice (Degagne et al., 2004). These doubts are related to the influence of the work coordination and organization capacity to transfer and use risk knowledge, in particular risk modeling knowledge. Thus, in fact, the RM concept has evolved to ERM for gaining understanding of the holistic view of risk in the organization in "a systematic and integrated approach to the management of the total risks that a company faces" (Dickinson, 2001).

The complexity of the ERM implementation is in identifying and coordinating the risk control actions across the organization. The risk analysis tools and information structures supporting risk analysis and control are independent of the organizational areas, with different views, specific objectives and processes. The independent treatment of risk has effects such as a different language within the organization to talk about risk ,and also the expertise of the analysts is not the same in different areas or applicable to different kinds of problems (Dickinson, 2001; Warren, 2005; Shaw, 2005). Marshal and Prusak (1996), Daniell (2000) and Shaw (2005) presented KM as a discipline that can contribute positively to the ERM implementation with regard to data and information management, risk knowledge sharing, analysis consolidation and reporting.

From the above concepts Risk Knowledge Management (RIKMAN) appears as the application of KM processes to support ERM. To get this support it is necessary to use an Enterprise Risk Knowledge Management System (ERKMAS) where the risk modeling process is a component. Thus, risk modeling process is part of ERKMAS and risk measurement process; although, mainly risk modeling is a subset of mathematical modeling where means are designed to access past experience, conceptualize, put into operation, develop and discover variables relationships using risk knowledge. Therefore, RIKMAN development needs the improvement of the capacity of risk modeling knowledge, because:

- First, risk modeling knowledge can provide meaning to information: "Risk Management is frequently not a problem of a lack of information, but rather a lack of knowledge with which to interpret its meaning" (Marshal and Prusak, 1996).

- Second, risk modeling knowledge is based on the measure of variability. RM is important because of the search of the maximization of the expected profits, which are exposed to potential variability that can be transformed into losses (Oldfield and Santomero, 1997). The causes of the variability can come from different sources: market, investments, operation, strategy and so on. The organizations are looking for solutions to reduce, to control and to mitigate the risks in order to achieve their goals.

- Third, risk modeling knowledge can deal with different kinds of risk. Banks have a broader exposure to risk demands requiring better understanding and development of risk modeling capacity. These risks are classified as (Van Greuning and Brajovic, 2003):

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

- Fourth, risk modeling knowledge supports and helps to mitigate doubts about the integral view of risk and the capacity of managing the potential losses as is required by Basel II (2004) Capital Accord. Risk modeling knowledge contributes to the main points or pillars considered in the accord: capital allocation, separation of the operation and credit risk, and alignment of regulatory and economical capital. To reach the Basel II accord requisites risk knowledge transfer plays an important role and in particular thinking in banks as information- and knowledge-based businesses (Fourie and Shilawa, 2004) where once a new risk is identified it implies that new knowledge is required (Shaw, 2005).

Table 2 shows four areas where risk knowledge is associated with ERM.

Table 2
Four Areas of Risk Knowledge in ERM Development

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 organization
Value & Cost of the information	Sutcliffe and Weber, 2003	The cost of knowledge introduces the need for 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

- Fifth, Dickinson (2001) introduced knowledge as a factor to reduce risk. Risk modeling knowledge is one of the pieces of knowledge to use. Table 2 includes areas where risk knowledge is associated with ERM and with risk modeling knowledge. Risk knowledge contributes to control, business strategy and underwriting processes because they depend on human actions and transfer knowledge has value in those processes. Knowledge transfer can be influenced by the existence of knowledge silos, as it could happen in risk modeling processes, and the business units can require answering how to transfer experiences (Horton-Bentley, 2006), taking into consideration that the speed of changes can reduce the value of experience in some specific fields (Hayward, 2002).

  There are different vehicles used for knowledge transfer—for example, the good use of the communities of practice at the World Bank (Wenger, 2000) or several methods and tools for collaboration; however, the value and way to develop knowledge databases is not clear (Samoff and Stromquist, 2001; McClernon, 2003). The same happens with the use of e-learning, CoP or others, which need permanent KM solutions with continuous access (Lamb, 2001). Solutions can be complemented by the importance of the social network, building trust for sharing and possible creation of inter-firm collaboration (Kubo et al., 2004). These inter-firm (with external clients) relationships affect the knowledge transfer and learning benefits (Uzzi and Lancaster, 2001). In general, the communication capacity of the organization can influence the risk knowledge transfer.

- Sixth, risk modeling knowledge, as a risk management process in banking, can facilitate knowledge transfer that is influenced by: difficulties of language spoken inside the organization related to risk and expertise application to solving different problems (Dickinson, 2001; Warren, 2005; Shaw, 2005). Additionally, risk modeling knowledge can provide organization to knowledge, defining problems, variables and their relationships, and support search tools to facilitate the search task if there is a high volume of knowledge available (Alavi and Leidner, 2001) or to organize the search tools that are crucial in RM (Simoneau, 2006).

In summary, RIKMAN and risk modeling knowledge can be developed through data and information management (Shaw, 2005), risk knowledge sharing, consolidation and reporting. KM and information management are needed for actionable answers to risk threats (Sutcliffe and Weber, 2003). In brief, the application of KM to ERM requires, on the one hand, the identification and development of knowledge processes, and on the other hand, the identification of the integral knowledge that a knowledge worker requires (in particular, the risk modeling knowledge).

3. Developing Risk Modeling Knowledge: A Method

This section presents the components of a method to support risk modeling knowledge. The proposed method requires the implementation of an ERKMAS. This system is the support of the interdependent dynamic among the movements between tacit and explicit risk modeling knowledge in a RIKMAN development.

- Socialization: social interaction among the risk management employees and shared risk modeling experience

- Combination: merging, categorizing, reclassifying and synthesizing the risk modeling process.

- Externalization: articulation of best practices and lessons learned in the risk modeling process.

- Internalization: learning and understanding from discussions and mathematical modeling review.

Figure 1 shows risk modeling knowledge as a common area among risk management processes in the organization. All these risk management processes create models to describe the phenomena. There is a possibility of using similar knowledge, techniques and tools to solve different risk problems. Figure 2 shows that in three main components of ERM there are links among data, search of problem solutions, policies and organization of outcomes such as risk modeling knowledge has been conceived. Based on these previous points, the proposed method looks to use the context and experience to improve the risk modeling process. Thus, the methodology proposed for developing risk modeling knowledge is composed of the following seven steps:

1. Answering the questions related to the strategy and strategic planning in the organization.

2. Identifying the enablers to transfer risk knowledge from tacit to explicit knowledge and vice versa.

3. Understanding of flows of information to produce knowledge.

4. Understanding risk knowledge organization.

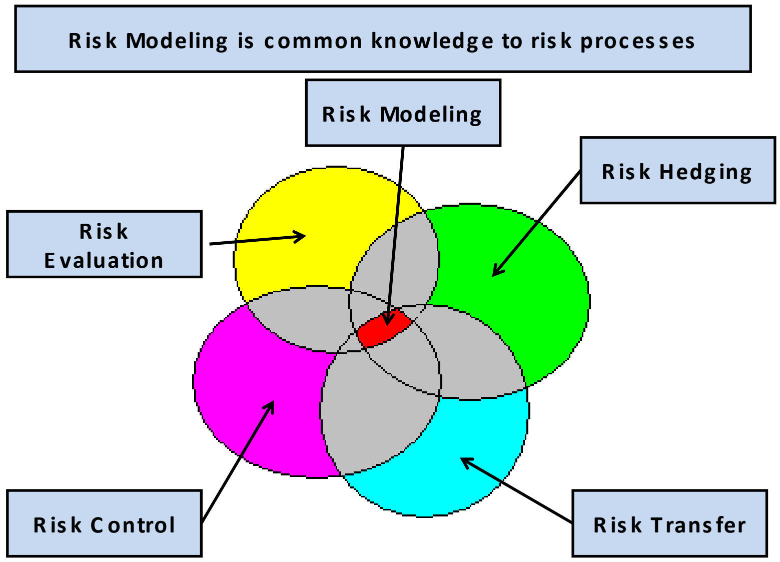
5. Searching for KM technologies and techniques.

6. Designing the ERKMAS to support risk modeling.

7. Connecting organizational performance metrics and risk modeling process.

The first step in the method is to get answers to questions such as: What resources does the organization need? What does the organization want? What does the organization measure? What is the impact? What has been the experience? What are the errors? Where is the failure based on lack of knowledge management?

Figure 1
Different ERM Processes Have Risk Modeling Knowledge as a Common Process



This method step is based on the needs of the stakeholders, their value definition and the strategy planning process. The risk modeling process is in agreement with the "design approach to planning" introduced by Ackoff (1981) following his five proposed phases: formulating the systems of problems, identifying ideals, objectives and goals, means planning, resource planning and design of implementation and control. In summary, the risk modeling process starts with the recognition of the strategic context and contribution that it will make to the strategic process.

Based on this strategic orientation, the second, third and fourth steps are associated with the understanding that individual minds and knowledge creation require three elements in order to discover KM and ERM process relationships: identification of the ways to transfer tacit to explicit knowledge and vice-versa (Nonaka and Takeuchi, 1995), clarity about the flows of information and how they produce knowledge (Choo, 1998; Weick, 2001) and understanding of the way that the risk knowledge is organized (Wiig, 1993).

The second step refers to enabler analysis of risk knowledge transfer studying traps, errors and constraints of the process. Transferring risk knowledge in both directions, tacit to explicit and vice versa, starts with the identification of traps in the decision-making process (Hammond et al., 2006) affected by the modeling process. The risk modeling process needs the understanding of risk knowledge transfer to tune up people's efforts and to reduce wrong application and interpretation of concepts, relationships and results. These traps are:

- "The mind gives disproportionate weight to the first information it receives."

- “Decision makers display, for example, a strong bias toward alternatives that perpetuate the status quo.”

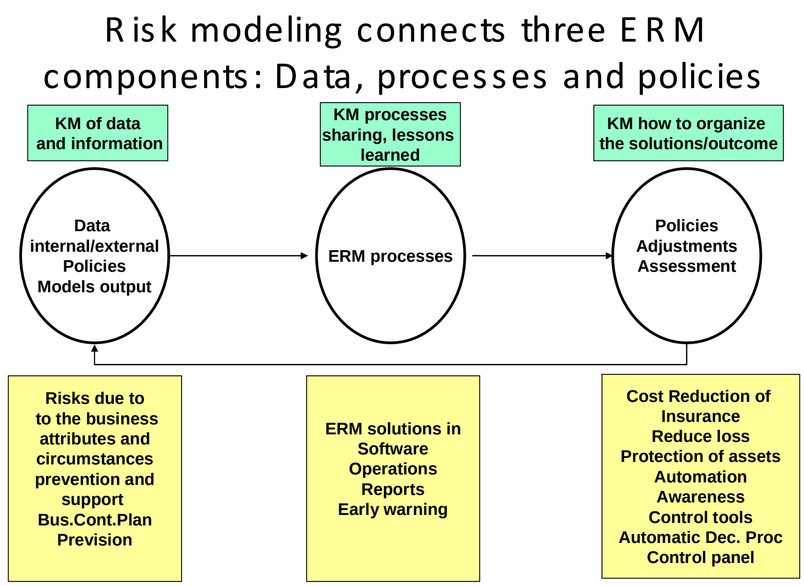
- “ … is to make choices in a way that justifies past choices…”

- “The bias leads us to seek out information that supports our existing instinct or point of view while avoiding information that contradicts it.”

- “The way a problem is framed can profoundly influence the choices you make.”

- “While managers continually make such estimates and forecasts, they rarely get clear feedback about their accuracy.”

Figure 2
KM Acts through Risk Modeling in Different Components of ERM Processes



And, at the same time it is necessary to clarify whether the models will be used for decision automation or for getting insight to problems only. For example, the automation of quantitative solutions in a trading operation can produce issues in a market if everyone is using the same strategy. For instance: “The report suggests that many of the quantitative portfolio construction techniques are based on the same historical data, such as value premium, size premium, earnings surprise, etc., and that there is a widespread use of standardized factor risk models that would explain why quant funds act in unison” (Avery, 2007).

Additionally, the risk modeling process can be affected by the process of transferring knowledge that produced risky exposure. The reason is that a lack of the coordination of knowledge processes, according to some examples of the financial practice, influenced losses:

- Expansion: Growth affected the operations at American Express. Expansion ran faster than growth of capacity. The knowledge support was minimal (Simons, 1999).

- Culture: The Banker Trust expansion reduced the quality of the product presentation to the clients. The reason was cultural pressures. 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).

- Controls: Barings Bank’s failure is related to the creation of early warning systems and the relationship to a work environment of rewards and recognition. A short term performance view and internal competition contributed to the bad results (Simons, 1999).

- Lack of understanding: what is happening, the complexity increment, transaction creation, lack of control, information management and cost as the only important factor to manage, reducing the capability to react in difficult and opportunity times. This complexity and the cost of knowledge show the need of managing the understanding and use of information rather than information itself (Sutcliffe and Weber, 2003).

- Lack of communication of business values in an understandable way that people can embrace. Possibly the identification of off-limits actions was not clear (Simons, 1999).

- Reduced stimulation of a learning system in order to review processes and to discuss the results and adequate diagnostic control systems (Simons, 1999).

Finally, to take into consideration that there are additional factors, to add to the above list, affecting the coordination of knowledge: new different workers’ mentality open to technology and with different communication means, in some cases a silo culture, are living at the same time with a larger desire of understanding and searching for solution of doubts; new problems with higher complexity and demanding transformation of organization to solve problems that require enterprise-wide answers with the appropriate technological support.

The third step relates to the understanding of flows of information to produce knowledge and how to use these flows in risk modeling. This means analyzing experiences of KM processes, methods and technologies used in risk management problems in order to develop risk knowledge management capacity. Some examples of the search for KM support in order to improve risk modeling knowledge are the following:

- Application of prediction and classification models (Burnstein et al., 2002) such as financial service technology and knowledge development of the organization.

- Data mining practice as a means to support the customer focus. Risk classification and loss estimation (Hormozi, 2004; Dzinkowski, 2002). The emphasis put on cost of integrating risk analyses, control and risk policy creation, deployment and application (Cumming and Hirtle, 2001).

- The emphasis on acquiring knowledge and problem solving or on increasing the orientation to people and processes (Edwards et al., 2002).

- Search of a solution of sliced risk management data (McGibben, 2004) and the development of solutions to control risk exposure, data structures to share them with different areas in the problem-solving process.

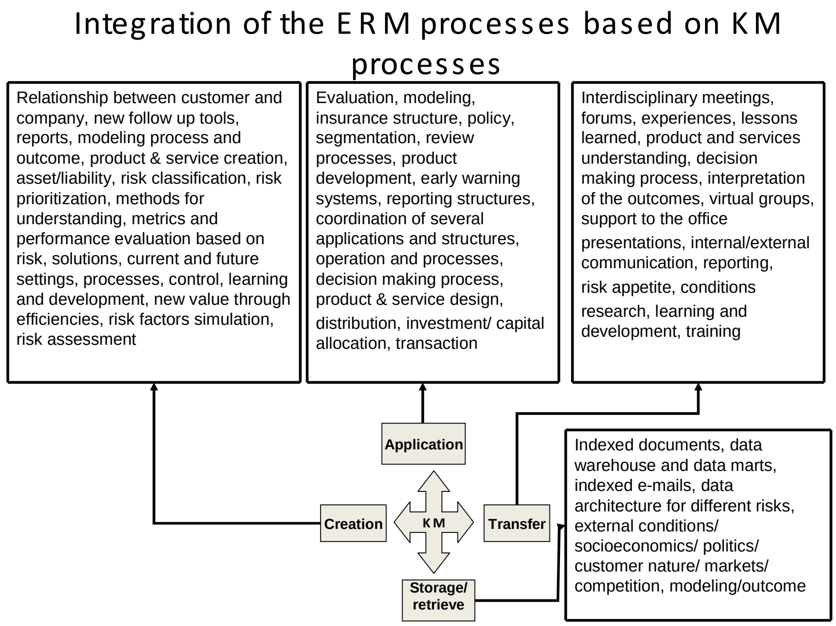
- Orientation to new technology for data and information management, and for the modeling process (Shaw, 2005).

The assumptions behind the decisions in hedging or investment can be different, and the lack of sharing can create issues in the RM processes and the controls may not be enough. The search of the truth outside of the isolation is something important in order to get better answers. Lack of knowledge access can create failures. Weak means for transferring knowledge can provide insufficient knowledge of the operation, poor assessments of the lessons learned and poor understanding of the present and forecasts through risk knowledge.

This lack of knowledge can be created because of interruption in the flow of information which is a component of the modeling work that is complemented and used properly by the expert. Goovaerts et al. (1984) wrote that only incomplete information is available, and it is the actuary who decides the principles and distributions to use. Information use, with interpretation and context content, or better to say knowledge, is part of the risk modeling process as a common area of risk management processes for analysis of market risk, operational risk, strategic risk, credit risk and actions of risk mitigation, risk transfer and risk capacity evaluation.

On the whole, the flow of information for risk modeling knowledge in ERM processes is related to the KM processes associated with risk assessment and risk knowledge creation. This flow of information uses data and follows a method for storing and retrieving raw and created data, and transferring results for knowledge applications. Figure 3 shows some of the examples of RM activities classified by KM processes.

Figure 3
Some Information Flows and Relationships that KM Processes Have with ERM Processes



The fourth step consists of understanding the organization of risk modeling knowledge. Risk modeling requires following the mathematical modeling process. Knowledge in the risk modeling process can be organized as a collaborative work and as the application of knowledge from different sources and disciplines.

The organization of risk modeling knowledge means to identify knowledge management processes of the mathematical modeling experience. This refers to getting clarity of what to do and to know and what the process to build a mathematical model is. Mathematics (Aleksandrov et al., 1969) has as characteristics: abstraction, demonstration and applications under precision and logic rigor. The abstraction is the search of quantitative relationships; demonstration is part of the human knowledge in order to get generalizations about these quantitative relationships of the set members.

The organization needs to develop capacity to solve problems and to provide support for the modeling process under the premises of (Mladenic et al., 2003):

- Decisions come from humans and machines. Machines include decision systems and humans use some theory frameworks and decision support systems.

- People-centric or people's mind management world—management is about knowledge and knowledge management is about people, processes, technology and organizational structure.

- The old computing is about what computers can do and the new computing is about what people can do. New computing is about: reliability, comprehensibility, universality, harmony with human needs.

- The power is not in having knowledge. The power is in sharing knowledge and using it to add value and to create a sustainable competitive advantage, similarly to thinking in KM and business processes instead of business processes and information systems.

- Technology is more than software or hardware is the answer to HOW to solve…? For example, modeling processes capacity is competitive capacity (Davenport, 2006).

The organization of risk modeling knowledge can use experiences of KM practice in mathematical development, under the previous premises, with two different points of view for this organization: first, development of communities of practice (Wenger, 2000) such as the group Bourbaki and the Cambridge Club 1930. In both cases, the scientific work was based on common interest, and the organization was formed by volunteer members working for a better development of the science. The group Bourbaki was composed originally of Henri Cartan, Claude Chevalley, Jean Coulomb, Jean Delsarte, Jean Dieudonné, Charles Ehresmann, René de Possel, Szolem Mandelbrojt and André Weil. The group was created in 1935 with the purpose of writing a comprehensive text of mathematics based on set theory and axiomatic foundation. There were meetings to review the content, to identify the production logic and to decide the structures and mathematical development. The main point was to create forums for discussion and ideas development based in formalism and axioms as Hilbert proposed.

Another means of knowledge collaboration was the one described by Foster (1985), who wrote about what he called the Cambridge Club 1930, "These four men did not comprise a school since they did not appear to have a common objective, but they knew each other and influenced each other and so might be called a club." Foster referred to Sir Arthur Eddington, Sir James Jeans, Bertrand Russell and A.N. Whitehead, all of whom were working at Cambridge at the end of 1930. The difference with the Bourbaki group was the regularity of meetings and the specific objective. In both cases, the knowledge transfer was fundamental to contributing to the mathematics formalization and to the new mathematical physics that was merged with the relativity, quantum theory and the uncertainty principle. These examples possess the attributes of the communities of practice presented by Wenger (2000).

Finally, a powerful example of modeling collaboration has been the open source development in our society. Access to multiple tools is a sample of what is possible to do with high levels of quality because of knowledge sharing for knowledge creation and knowledge application. Some examples of this modeling collaboration are: R, Octave, Content Management Systems and many other software solutions that are possible to apply to different problems.

A second point of view for using KM experience is to recognize a learning process in organizations (Senge, 1990). Knowledge discovery and knowledge transfer from other disciplines have been used for the solution of risk modeling problems. There are some examples of theories coming from general stochastic processes analysis, such as Compound Poisson Process, Brownian Motion (Karlin and Taylor, 1998), or from other observations, abstraction and reference theories, such as fractal geometry, symmetry analysis of the nature, which represent knowledge transfer from other disciplines to risk management. The Brownian motion theory coming from physics is a basis for financial mathematics or as the application of the general stochastic process martingales and compound Poisson processes are to the financial models and loss distribution modeling. The symmetry study through group theory is an example of starting from the observation of geometric figures to apply concepts to many different mathematical branches and practical problem solutions in many disciplines. In addition, discovery of risk modeling knowledge can develop innovation and application of methods and outcomes to problem solving in other disciplines.

Additionally, learning in organizations emerges from the experience analysis and the identification of sub-processes in a risk modeling process; this means recognize steps in the building model process that facilitate the identification of tasks and sub-processes that are based on knowledge and can be oriented and used in different problems. The identification of the sub-processes of three risk modeling examples is based on the work of Carnap (1966), Raiffa (1968) and Leonard (1998). Carnap introduced the idea of a law in science as statements expressing regularities in the world. He identified that not all the laws are universal but, as he called them, statistical laws. The risk modeling process belongs to the search of statistical laws and, as Carnap said, the process starts with direct observations of facts that in risk management are called claims, losses and exposures. Additionally, these laws are used to “explain facts already known, and they are used to predict facts not yet known.”

Now, Raiffa (1968) introduced the decision analysis and he identified the value of the outcome of the models based on the relevance in a real-world problem. He said, “In these lectures I have indicated how a decision maker’s preferences for consequences, attitudes towards risk, and judgments about uncertain events can be scaled in terms of subjective utilities and probabilities and how these can be incorporated into formal analysis. By these means it may be possible in some circumstances to reduce the judgmental gap and to bring the output of the model closer to the demands of the real-world problem; the model will then have more a chance to pass the test of relevance.” In this article this reflection is part of the identification of the sub-processes of risk modeling that include understanding, interpretation and possible application to other problems.

In order to complement Carnap’s (1966) and Raiffa’s (1968) views, the Leonard’s model (1998) is used. This model, called “knowledge creating and diffusing activities,” considers a cycle where core capabilities for shared problem-solving in the present are connected to implementing and integrating, experimenting and prototyping, and importing and absorbing knowledge. The core capabilities have to reduce the core rigidity that is coming from skills and knowledge, managerial systems, physical systems and values. Sub-processes in risk modeling processes are looking for a better knowledge development in order to use knowledge to different problems.

Based on the above ideas, the next examples (Tables 3 and 4) provide an identification of the attributes of mathematical modeling that are used for risk analysis and that share common knowledge following the steps proposed by Klugman et al. (1998). These examples are: the use of compound Poisson for loss distribution modeling, a modeling process for risk classification and a modeling Markov process for credit risk evaluation and behavioral prediction. From the review of these three examples it is possible to identify four main components in each modeling process: information management, mathematical work, experimenting and prototyping, and communicating. These four components of the modeling process are presented in Tables 3 and 4 divided into sub-processes identified as common. These sub-processes are going from data gathering up to application of the theoretical concepts to different kinds of problems.

Table 3
First Group of Sub-Processes Describing the Modeling Process of Problem Definition and Data for Three Different Problems

Three different problems that have different risk model sharing similar knowledge.			
Process	Risk Classification	Loss distribution Compound Poisson Process	Markov process for credit analysis
Problem Definition			
Problem definition: understanding the phenomenon	Meaning of customer classification, attributes available, timing, groups etc.	Concept of loss, claim process, cost associated, income associated, reinsurance, recoveries	Classification proecedure, identification of units and amounts of credit, differences, trends, sectors, markets
Search for general models/theoretical support/mathematics	New theory for parameter estimation, testing new models decision trees, regression trees, neural networks…GLM	New approaches for numerical and analytical solutions of the stochastic processes	New approach for transition. Time series review, comparison, GLM, Markov chains discrete, continue, absorvent etc.
Reducing the core rigidity			
Reducing the core rigidity: People coordination/project development	Expert identification, blueprint, maps, plans. Blocks & Steps definition, capacity and roles identification	Expert identification, blueprint, maps, plans. Blocks & Steps definition, capacity and roles identification	Expert identification, blueprint, maps, plans. Blocks & Steps definiton, capacity and roles identification
Data gathering	Data experience, profile variables, default definition,claims data, exposure set definition, clustering for outliers	Claims data, recoveries, reinsurance, investment, clustering outliers identification	Classification of loans, default definition, identification of age groups. Clustering outliers identification
Data store	Data mart creation/access, record selection, variables-fields selection	Data mart creation/access, record selection, variables-fields selection	Data mart creation/access, record selection, variables-fields selection
Data selection/ preparation	Learning set, out of time, out of sample	Different periods of time, simulation points, empirical distribution, descriptive statisitics	Data from different groups in different period of time, comparison of results
Data for control	Selection of the samples, out of time and out of sample	Different periods of time, simulation points, filters	Using automated process, discretization, programming the portfolio
Programming/specialized software	Testing assumptions, normality…, Modeling, categorization, regression process, models identification, models preparation	Histograms, ways to estimate parameters, distributions simple and mixed. Tail analysis	Matrix definitions, develop test of absorving states, properties of markov matrices. Discretization process

Table 4 shows sub-processes from problem definition up to data manipulation. Table 5 presents the way to pass from discovering relationships and modeling initiation up to getting the solution applicable to other kinds of problems. This means application of the knowledge gained to get new solutions, possibly with different data and relationships.

Table 4

Second Group of Modeling Sub-Processes From Modeling Tests up to the Search of New Model Applications

Three different problems that have different risk model sharing similar knowledge			
Process	Risk Classification	Loss distribution Compound Poisson Process	Markov process for credit analysis
Prototyping			
Prototyping: Model/program Testing definition of structure and relationships/model structure selection	Input data to different models	Input data to different models	Input data to different models, identification transition matrices multiple steps, absortion, properties of the matrix type
Parameters estimation and solutions of relationships-equations	Testing different methods	Testing different methods	Testing different methods
Model performance evaluation	ROC, classification tests, Kolmogorov-Smirnov	Fit tests, Kolmogorov-Smirnov, Chi-Square,	Testing assumptions Markov property, normality…
Model improvements	Identification of different set of variables, parsimonuos metrics, testing more variables	Identification of special cases	Time forecast, continue and discrete
Reporting	Problem solved, scope, model specifications, results, interpretation, new challenges and priorities	Problem solved, scope, model specifications, results, interpretation, new challenges and priorities	Problem solved, scope, model specifications, results, interpretation, new challenges and priorities
Reducing the judgment gap			
Reducing the judgement gap: Results interpretation	Meaning of classification	Meaning of loss distribution and applications	Identification of states and probability movements
Communication	Presentations to different groups, taking feedback	Presentations to different groups, taking feedback, developing new options	Presentations to different groups, taking feedback, developing new options
Search of the statistical law			
Search for a statistical law: New generalizations/weak assumptions	Look for panel data, time series indicators	Mixed distribution and special groups for managing claim. Relattionships with marketing, pricing	Description with different stochastic processes modifying some assumptions
New applications/input new models	Developing variance metrics, identification new significant variables, benchmarking, development of segmented models (economical sectors, by different clusters)	Loss given default, behavioral models, preventive dashboards, risk indicators management	New structure of portfolio classification, market segmentation
Many steps have common knowledge that need to be aligned and to produce capacity for risk modeling. For instance: describing groups,(groups can be defined as the sets of customer according to the due-date, delinquency level) clustering, selecting variables from linear approach, classification process profile of payment quality. There is a basis on the loss distribution for other applications such as calculating maximum loss probability. The groups of debt quality can be organized in a different way, producing a sequence of the credit process from selection to control of credit portfolio			

Generalization of a risk model can depend on the assumptions, theory, time and data available. For example, time is a factor affecting whether the model is discrete or continuous on time. This has a big impact in risk management modeling. In all these steps, knowledge is a component to organize and to promote in order to achieve answers and to identify how to improve assumptions and methods.

The capacity for risk modeling development is about how people learn to work independently and how to work simultaneously with others, coordinately and looking at the forest and not just the trees. The challenge is that organizations need to coordinate resources under the understanding that they have knowledge workers and problem solvers and not workers and jobs. Furthermore, the organizations have problems to solve and not just tasks to do, which implies that organizations have managers and analytics professionals living together. This requires organization of risk modeling knowledge and ability to use common knowledge in mathematical modeling.

The fifth step refers to identifying the KM processes and how to support the use of common knowledge of risk management processes in mathematical modeling. The risk modeling process needs to be supported in order to mobilize information flows to produce risk knowledge through a clear role of KM processes as a means to consolidate, integrate and organize the risk knowledge. This can happen in the following way: knowledge creation where knowledge is represented by risk assessment; knowledge storage and retrieval through the data support for external and internal users; knowledge transfer using the experience of many people in known cases; and, knowledge application to discover business processes opportunities. These KM processes in a risk modeling process are described in detail as follows.

Knowledge creation: This means to identify assumptions, conceptualization process, identification and selection of techniques to use, selection of processes, development collaboration, methods of solution, prototyping models and testing. Knowledge is in developing new models, replacing existing models, promoting new solutions, participating in problem solving, organizing product development and risk evaluation for innovation. From the technology side, knowledge is created for providing access to models and results, for managing technological support as intranet, developing external solutions/answers methodology for problem solving, increasing the sophistication of solutions, managing data/quality, analyzing multi-risk, and selecting solutions development and accessibility.

Knowledge storage and/or retrieval: There are many different components in risk modeling to store and retrieve such as: documents, raw data, data created, taxonomy, metadata, and structured and unstructured data. The action of storing and retrieving implies cleaning data, developing and implementing documentation process, structuring information, codifying human knowledge with comments of tacit knowledge from individuals and groups. There are measures to develop for identifying the quality data repository, data volume, codified documents/indexed/structured processes to update, metadata structure, comfort with data repositories, documentation incentives, technology used for repositories, process to populate data, document standards and process to access and use of data repositories.

Knowledge transfer: Risk modeling knowledge can be transferred through presentations, portals, meetings, discussions, collaboration activities, content management design, distribution and testing reporting. There are differences to consider when there is transferring knowledge between individuals, individuals to groups, between groups, across groups, groups to organization. All of these differences require actions among the participants to improve the communication processes and willingness to share by fostering the existence and richness of transmission channels such as: unscheduled meetings, informal seminars, coffee breaks, quality of knowledge transfer channels, taxonomies, metadata, forums, bulletins, interdisciplinary solutions search, feedback sessions, discussing forums and so on.

Knowledge application and learning: Application of risk modeling knowledge is represented by decisions, business processes and models in other organization areas such as: impact analysis, evaluation, new developments, new solutions of strategic and tactical decision.

Application is in the process of organizational performance evaluation, testing results, defining and implementing directives, organizational routines, process and technology updating, accessibility, work flow automation, training and experience support, business understanding, results interpretation, speed of the application and risk cases access.

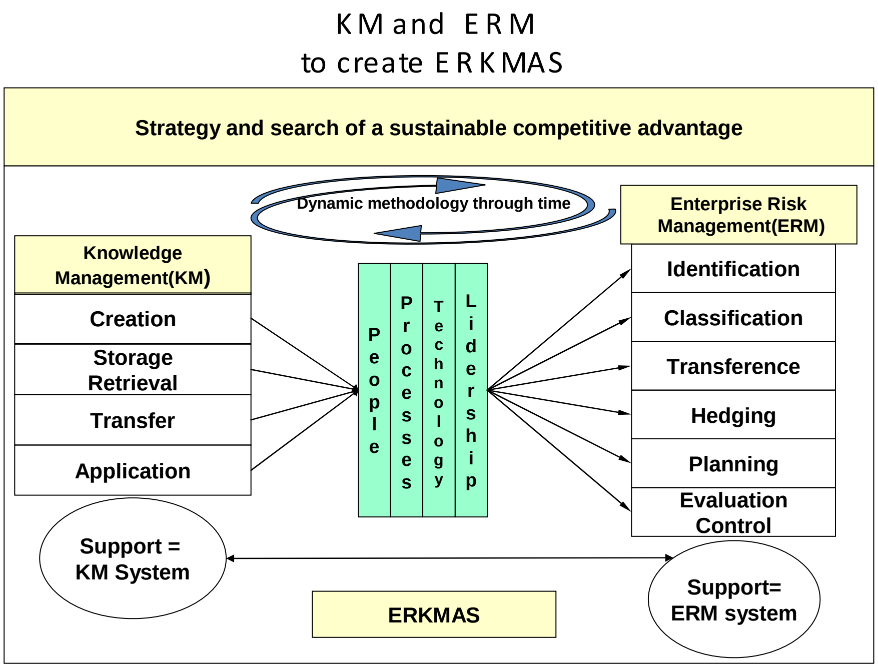
The sixth step is the ERKMAS design to support the risk modeling process. Davenport et al. (2005) presented that analytics is a strategic capacity that the organization can have and develop for competing. Analytics work requires information systems support. However, risk management information is based on a context; it requires interpretation, this means to design and to develop an ERKMAS. Information without knowledge of the context could be dangerous. Risk management does not have just a problem with information; it has more problems with interpretation and communication of meaning.

Companies are competing to optimize their performance on analytical capabilities, which represents getting access to quantitative expertise, capable technology environment and appropriate data. This analytics capability of risk modeling requires the ERKMAS to support what Pfeffer and Sutton (2006) called the craft of managers that needs to be learned by practice and experience and the use of evidence as a means to constantly update assumptions, knowledge and skills.

The ERKMAS has to go further in managing data and information. As Apte et al. (2002) said, the problem is not just to describe what the organization needs or the request; it is to predict, to optimize and to classify. This means knowledge production, improvement of the attributes and overcoming the issues of the ERKMAS design. For example, in actuarial science there is a process of building statistical models describing the claims behavior, creating different policies and adjusting models according to contract clauses of the products and their potential claim development. Zack (1990) refers in general terms that an ERKMAS as expert systems have contributed to providing competitive capabilities to the organizations but the bases are in the capacity of acquiring risk management knowledge as it is used in some reinsurers.

There are three attributes of ERM challenging processes and technology—integral, comprehensive and strategic view (Abrams et al., 2007). This complexity is observed when the modeling process is looking for aggregation analysis when each organizational section can have different performance, problems and resources from the whole organization. Thus, the ERKMAS required is a dynamic bridge (Figure 4) between KM processes and ERM processes passing through people, business processes and technology.

Figure 4
ERKMAS is the Support for Joining KM Processes and ERM Processes



This bridge is the connection between processes and in particular in risk modeling the use of data with different shapes: structured and unstructured. The bridge is the support to the outcome of the models for interpretation using context, which is in most cases unstructured data. The risk modeling process design, coordination and understanding are part of the knowledge used in the decision-making process. Some KM technology and techniques (Ruikar et al., 2007) are possible to use in different levels of the design, coordination and understanding of the risk modeling process. Thus, KM technology uses IT, with focus on explicit knowledge, and KM techniques use people learning with a focus on tacit knowledge. KM technologies support the risk modeling process in tasks such as reading data, monitoring data quality, retrieving data and supporting software structures for quantitative analysis. These technologies are associated with data mining, data warehousing, project management, intranets, extranets, portals, knowledge base, taxonomies and ontologies or in explicit technological solutions for learning, content management, collaboration or management of work flow.

KM techniques supporting the risk modeling knowledge process are associated with interdisciplinary work, interdepartmental work controlling the whole process from problem definition to solutions evaluation. Some of these techniques are: communities of practice, forums, training, conferences, post project reviews, mentoring, yellow pages and so on. In summary, a goal is to build an ERKMAS in order to support decisions or, as Davenport and Harris (2005) said, to align the organization to the age of the automated decision systems applying codified knowledge and providing decisions plus a knowledge sharing environment. The human intervention is identified as a means to confirm decisions and to analyze particular cases, which means the use of knowledge for a risk solution.

As the seventh and final step, the ERKMAS design is complete when the performance evaluation sub-system is designed. This step means getting answers to questions such as: how to measure, to interpret and to discover directions of the organization performance connecting risk metrics with risk modeling. There is a search, in this step, for cause-effect indicators related to the risk modeling process and other risk management processes. One of the points of the Basel II compliance is to build risk-adjusted performance management (RAPM). RAPM comprises risk model development, and the construction of risk models requires the understanding of indicators used for enterprise performance evaluation.

KM is related to performance measures using the relationship between the four types of organizational capital (Fairchild, 2002): intellectual, human, social and structural. The BSC (Kaplan and Norton, 2004) contributes to using strategy maps to provide a meaning to the intangibles and their influence in the risk modeling process. The inclusion of risk factors and intellectual capital concepts in the balanced scorecard can be a step ahead in the performance evaluation processes relating KM and ERM. However, more than the metrics for organization performance evaluation, the point is in the process to build the metrics relevant when risk is involved (Wu, 2005). Besides, the KM metrics (Rao, 2005) can be connected to the BSC in different fronts and settings.

The BSC can lead the creation, formation of the strategy of intellectual capital and its fortification (Wu, 2005).The integration of the internal perspective, learning and growth and the strategic process of the intellectual capital are a direct consequence of the BSC use. Measures of intellectual capital (Fairchild, 2002) use metrics for financial processes, business processes, learning, client and human development combining components of intangible assets, growth, renovation efficiency and stability. Fairchild (2002) explains that KM and BSC can be connected by management of resources with focus in combination of resources of intellectual capital with the processes of the organization.

In summary, the KM metrics can be included in the BSC, and some approaches are done relating risk factors, intellectual capital and BSC, but not the whole evaluation process of the organization performance under risk. Barquin (2001) identified that managing and leveraging knowledge is crucial for improving organization performance; however, risk was not included as a factor to evaluate. As a complement, Shaw (2003) presented the risk performance adjusted measures and the process to calculate them. These processes are part of the KM processes in the sense of using data, creating models and interpreting the results and, as Fairchild (2002) said, related to intellectual capital management. However, the integration of the risk measures to the BSC is not evident. There are two ways to develop risk based performance measures. One is working directly from the definition of the indicators and the inclusion of the risk components in tangible and intangible assets. Another is to build special indicators (Albretch, 1998) as RAROC (risk adjusted return on capital) and RORAC (return on risk adjusted capital) for example, in order to relate return, expected losses and exposure. In any case, the ERKMAS design requires data architecture and software to support combinations of cause-effect development where the risk modeling processes are involved.

4. Conclusions

1. KM is a discipline that is associated with ERM. The KMS needs to support ERM processes development in common and different dimensions of the ERM processes. A better ERKMAS can provide a support to the risk modeling process as a common process in ERM.

2. General organization issues and development of processes are required in order to identify means for modeling improvement and support to the roles associated with the risk modeling process.

3. Risk knowledge includes modeling risk and its management is needed for effective and efficient development. There are tools to share knowledge and to produce results in the decision-making process and risk modeling process that need identification, alignment and use.

4. The methodology summary for the development of risk modeling knowledge is:

   - Answering the questions related to the strategy and strategic planning in the organization.

   - Identifying the enablers to transfer risk knowledge from tacit to explicit knowledge and vice versa.

   - Understanding of flows of information to produce knowledge.

   - Understanding risk knowledge organization.

   - Searching for KM technologies and techniques.

   - Designing the ERKMAS to support risk modeling.

   - Connecting organizational performance metrics and risk modeling process.

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