Journal of Civil Engineering and Construction Technology Vol. 2(11), pp. 242-252, November 2011
Available online at http://www.academicjournals.org/jcect
ISSN 2141-2634 ©2011 Academic Journals
DOI: 10.5897/JCECT11.024

Full Length Research Paper

Risk identification techniques knowledge and application in the Brazilian construction

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Accepted 28 July, 2011

The purpose of this study is to assess the use and knowledge degree of risk identification techniques in the construction industry. They are classified in residential housing construction, institutional and commercial building construction, specialized industrial construction, infrastructure and heavy construction. Therefore, we conducted a survey research by applying a questionnaire among professionals in the construction industry. When we compared the results to literature, we verified that, according to the results, the risk identification techniques more frequently applied in construction in Rio de Janeiro State (Brazil) are Checklist, Flowchart and Brainstorming, which partially is according to what is found in the literature. Nonetheless, not all the techniques mentioned in literature are known by the professionals.

Key words: Risk identification technique, survey, construction.

INTRODUCTION

The construction industry in Brazil has been expanding very much its participation in the market, mainly because of the increasing demand of oil and gas and building construction industries. Besides, the quick access to information accelerates the technological changes, characterized by complexity and innovation. These factors make it necessary to improve and to review the concept of this industry with regard to management of their projects. In accordance with Ferreira (2009) the recovering of the construction area is very important to the engineering services sector.

Faced with this increase of demand, we verify that it is necessary to include risk management in project planning and management so as to identify, assess, manage and control the risks that would be adverse to the project goals (Kerzner, 2002).

In Brazil, we know that the construction industry has a great importance in economy due to the increase of investments and the job opportunities generated. Therefore, part of the organizations inquired adopts a process for risk management. However, in some of them the risk management has not been sufficiently promoted and, consequently, it is not fully applied.

This theme is relatively new, though, since this methodology was elaborated in the last decade and the companies have been adopting it in their projects in the lasting years. Indeed, the risk identification phase was considered by many studies in this area as the most important phase in the risk management process. During this phase there are a lot of identification techniques that could help the identification process, but the results of the application of these techniques are little known in Brazil yet.

As we recognize the importance of the construction industry, as well as its significant exposure to risks and the importance of the risk identification phase, the aim of this article is to assess the degree of knowledge and utilization of risk identification techniques in the

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construction segments of buildings, construction, infra-structure works and construction specialized services. Therefore, we conducted a research in literature about risk identification techniques in addition to a posterior application of research “survey” among the professional of the construction area. The study was realized in Rio de Janeiro State (Brazil).

LITERATURE REVIEW

Risk definition

There are a lot of definitions of risk in literature. For some authors, risk is defined as the possible occurrence of negative or adverse effects that lead exclusively to damage or loss, whereas other authors define it as the possibility of occurrence of either negative or positive effects such as: Royal Society, 1991 (as cited by Edwards and Bowen, 1998), Rowe, 1977 (as cited by Zou et al., 2007), Al-Bahar,1988 (as cited by Ghani, 2005), APM BoK (APM BoK - APM, 2000), ISO (ISO 31000 – ISO, 2009), Birch and McEvoy (as cited by Akintoye and Macleod, 1997), Bufaied,1987 (as cited by Akintoye and Macleod, 1997), Chapman, 2003 (as cited by Raftery, 1994), Jaafari,2001 (as cited by Morano, 2003), Kerzner, 2001 (as cited by Morano, 2003), Lapponi, 2000 (as cited by Morano, 2003), Limmer,1997 (as cited by Morano, 2003), PMBOK Guide PMI (2008), Porter, 1981 (as cited by Akintoye and Macleod, 1997), Pritchard, 1996 (as cited by Morano, 2003), Raftery (1994), Valeriano, 2001 (as cited by Morano, 2003), Max, 1992).

In this research, the risk was considered as related to an event that has adverse effects. “In such a case, we accept the risk definition as being the possible occurrence of an undesirable outcome as a result of any event” because it is considered to be the most used in the construction industry (Valeriano, 2001). However, we do not intend to nullify the other definitions.

Besides, some authors establish a difference between pure risk and speculation risk. According to them, the pure risk may only result in loss or lack of profit and is out of the decision's control, like the risk associated to the occurrence of natural phenomena, as storms and tornados. The speculation risk, however, may result in either loss or profit, depending on the decision's choices (Adler et al., 1999; Investopedia ULC, 2010).

Finally, it is important to notice the difference between risk and uncertainty. In general, risk can be measured or quantified, and uncertainty cannot. Nonetheless, some authors do not agree with this differentiation (Ghani, 2005; Öztaş and Ökmen, 2004; Morano, 2003).

Ferreira (2009) considers the following difference between risk and uncertainty:

1. Risk –quantifiable, statistical assessment; objective data;
2. Uncertainty – not quantifiable, subjective probability, formed opinion.

Risks in construction projects

The perception that the construction industry is the most exposed to risks and uncertainty is a consensus among authors because of the very nature of its activities (Akintoye and Macleod, 1997; Dey, 2001).

Still, we found different approaches in literature with regard to the factors and characteristics of projects that expose the construction industry to mount risks. Dey (2001), for example, establishes the following: changes in the environment, the complexity of planning and design, the presence of various interest groups, resource availability, climate change, economic instability and political and regulatory statutes. In turn, Zou et al. (2007) mentioned long, complicated process, complicated environment, and the need for investment-intensive, dynamic organizational structures, technological and organizational complexity and the diverse interests of stakeholders (stakeholders). Ghani (2009) points out as factors and main characteristics high life cycle design, size, complexity, location, the different parties involved and familiarity with the performer's work to be done. Zeng et al. (2007) mentions: constant change of environment, direct exposure to hazards, high pressure involved in the compliance of costs and deadlines, and increasing complexity of construction techniques. Moreover, Shen (1997) highlights how the main features: the large number of people with different interests and abilities necessary to coordinate a wide variety of interrelated activities. Also, in the study conducted by Chapman and Ward (2003) the variability in the performance objectives of cost, time and quality, the ambiguity associated with various aspects such as lack of clarity due to the behavior of actors involved, as well as the lack of data and detail, are listed among the main factors.

Risk identification and risk identification techniques

Over the years, in order to give a systematic approach to risk, organizations and researchers have defined or cited several models of risk management. Still, the systematic risk management, in general, can be basically divided into three steps: (1) identification, (2) analysis, (3) response actions and control. Some authors define the risk identification phase as the moment in which we determine the risks that might damage the organization and its projects, as well as recognizing their characteristics (PMBOK - PMI, 2008). It can also be characterized as “the process of determining what will happen, and how it will occur” (Baccarini, 2001).

Other authors, however, consider the risk identification phase as being either one of the most important stages within the risk management process, (Martins, 2006) or even the most challenging and relevant phase in this process (Kloss-Grote and Moss, 2008).

Chapman (1998) divided the risk identification phase into three categories:

1. The Risk identification conducted only by a risk analyst and based exclusively in his practice, knowledge and capacity. This expert will take into account the revision of the project life cycle, as well as organization historical data;
2. The Risk identification was conducted through the interview of the risk analyst with one or many members of the project staff in order to analyze the reviewed data and the project life cycle based on the knowledge and expert of the people interviewed;
3. The Risk identification in which the risk analyst guides one or many work groups applying the risk identification techniques.

In such case, we find a lot of risk identification techniques in literature that will be explained below in a resumed form as follows:

1. Brainstorming – An idea generation group technique is divided in two phases: (i) idea generation phase, in which participants generate as more ideas as possible (ii) idea selection phase, in which each participant supports his/her idea in order to convince the others. In this second phase, the ideas are filtered, remaining only those approved by the entire group. This technique has four basic rules: "(i) Criticism is ruled out – evaluation of ideas must be withheld until later; (ii) 'Free-wheeling' is encouraged; (iii) Quantity is wanted – the greater the number of ideas, the more likely is the chance of having useful ones; (iv) Combination and improvement" (Morano et al., 2006).
2. Delphi Technique - "Delphi is a technique to obtain an opinion consensus about future events from a group of experts. It is supported by structured knowledge, experience and creativity from an expert panel, presupposing that a properly organized collective judgment is better than an individual opinion" (Wright and Giovinazzo as cited by Morano et al., 2006).

This consensus building technique uses written responses instead of a physical group meeting. Indeed it is a method that requires systematic gathering and critical comparison of judgments from anonymous participants physically isolated about a specific subject, with the use of a set of questionnaires carefully prepared, interspersed by summary information and feedbacks derived from previous responses (Morano et al., 2006).
3. Influence Diagram - It is a graphical representation containing nodes representing the decision variables of a problem. A traditional influence diagram is formed by three types of nodes: utility, decision and chance; and by two types of relationship: causal and informational. The causal relationship occurs between utility and chance nodes and represents a probabilistic dependence. The informational relationship occurs between decision nodes and represents time precedence (Morano et al., 2006).
4. Interview/ Expert Judgment - unstructured, semi-structured or structured interviews individually or collectively conducted with a set of experienced project members, specialists or project stakeholders (Morano et al., 2006).
5. Checklist - It consists of a list of items that are marked as "yes" or "no", and could be used by an individual project team member, a group or in an interview. (Morano et al., 2006)
6. Nominal Group Technique - The Nominal Group Technique was designed to be used in the planning activity in order to increase group's creativity, facilitate its decision, stimulate the generation of critical ideas and work as an idea grouping tool. This technique is composed by a silent generation of written ideas; a presentation of the ideas generated using simple sentences in postcards or paper band; discussion about each recorded idea for clarification and evaluation; individual idea ranking with those been mathematically aggregated to yield a group decision (Morano et al., 2006).
7. Flowcharts - Graphical tool that shows the steps of a process. This technique is applied for a better comprehension of the risks or the elements interrelation (Morano et al., 2006).
Scenario Building – It is characterized by the development of hypothetical scenarios that represent the processes to be developed through the logical construction of each event, as well as its interactions and results. While examining the project scenario, it is necessary to verify if there are risk events that can occur simultaneously and if the variations between them are high or low; identify the risk trigger, this means, the cause of the generation of high and low risks by a group of variables; plan a scenario with uncertainty variables and correlate them, computing their impacts on the project; identify the risk factors, such as new technology, an excessively optimistic estimating, or a possible problem with the work force; compute the impacts on the project's objectives caused by risk triggers; and combine the occurrence of possible events and the correlation among them through simulation techniques (Morano et al., 2006).
8. Pondering – "It is a simple and basic approach involving the use of one single person to identify risks and 'may serve as a default option if other approaches are not feasible or suitable'" (Chapman and Ward, 2003). Therefore, it is necessary by this person a previous field experience in which risks are been identified. During the practical application of this technique the individual considers or ponders the problem, generating a list of options (Morano et al., 2006).
9. Root Cause Identification - It is a graphical process used in the investigation and categorization of the essential causes of project's risk divided in four phases:

data collection, causal factor charting, root cause identification, recommendation generation and implementation (Morano et al., 2006).

10. Cause-and-Effect Diagrams – These are also called Ishikawa diagrams or fishbone diagrams, illustrate how various factors might be linked to potential problems or effects (PMBOK – PMI, 2008). The diagram is designed by listing the effect on the right side and the causes on the left side. There are categories for each effect, and the main causes must be grouped according to these categories (Morano et al., 2006).

11. Questionnaire – It consists of questions at the attribute level, with specific tips, examples and questions for subsequent investigations. In general, the questionnaire is tailored to each software development project in particular, and for each development phase. The questionnaire application occurs in two phases: (1) Question and Answer Phase; (2) Issue clarification (Morano et al., 2006).

12. SWOT Analysis (“strengths”, “weaknesses”, “opportunities”, “threats”) – It is a strategic planning tool used to evaluate projects, business or any other situation that involves a decision. Its application consists in the project evaluation in each of the four perspectives: strengths, weaknesses, opportunities and threats, generally presented in a quadrant charter (Morano et al., 2006).

13. Synectics – Its purpose is to solve problems in a creative way, so it consists in the union of apparently different and irrelevant objects and ideas. For this reason, it is recommended to use elements without connection in analogies or metaphors so as to enable the comprehension of the problem. The participants need to have essential attributions in order to apply this technique, such as a great imagination and conviction in their points of view, once they have to connect the problem with the metaphor. On the other hand, the use of a metaphor divides the group opinion, since there will be divergences in the association with the problem in focus. However, the challenge is to identify only the positive aspects in which the metaphor could be applied and develop options to solve the problem. In general, the rules of a Synectics and a brainstorming session are very similar; both of them include the presence of a facilitator to conduct the session (Morano et al., 2006).

14. Case Based Approach – This technique is based on the Cognitive Flexibility Theory, that is, the human ability to restructure the knowledge to solve a problem when the situation changes. In this manner, it uses the case as the approach focus, in which each case could be decomposed in smaller cases, and then disassembled (Morano et al., 2006).

15. Electronic Brainstorming – The electronic brainstorming has the purpose of generating ideas over the web through networked computers, in which participants have a fast access to the ideas generated and are able to develop new ones (Aiken et al., 1994). This technique is an enhanced version of the traditional brainstorming, since participants have their anonymity guaranteed and a group similarity. Once a participant cannot influence or dominate the group it is possible to overcome problems generated by differences in the levels of hierarchy, professional experience and knowledge. Besides, it enables the parallel communication among the group members, who can post simultaneous commentaries and contribute with new ideas, resulting in a great number of ideas. Another characteristic is the record automation, which allows the storage of all commentaries and ideas generated (Morano et al., 2006).

16. What if? SWIFT structure – The original SWIFT was developed as a simpler alternative to the HAZOP (Hazard and Operability) – The purpose of this technique is the identification of hazards and problems concerning the operability of installations.

SWIFT is a systematic study based on the group. In this study, a set of words or short phrases is used by a facilitator inside the office so as to stimulate the partnership in the identification of risks.

Therefore, the facilitator and the group use the standard phrases as “What If” together with words or short phrases. This is used to investigate how the system, the industry item, the organization or the proceedings are affected by behavior deviation or normal operation. SWIFT is applied normally in more than one system level with fewer details than HAZOP (IEC/ISO 31010, 2009).

17. Business Impact Analysis - The Business Impact Analysis is also known as Business Impact Assessment. This technique analyzes how the fundamental disruption risk can affect the operation of the organization, as well as identifying and quantifying the resource necessary to its management. The technique foresees the following understanding:

i. Identification of the critical level of the fundamental process of the business, its functions and associated resources and the fundamental interdependence existent in the organization;
ii. How the negative events will affect the capacity and ability to extend the critical aim of business;
iii. The capacity and ability necessary to management the impact of disruption and the organization recovery to the according levels of the operation (IEC/ISO 31010, 2009).

Despite the considerable amount of risk identification techniques above, we verified that the five techniques most quoted in the literature are: Brainstorming, Delphi Technique, Interview/ Expert Judgment, Checklist and Influence Diagram, with special emphasis to Brainstorming, Interview/ Expert Judgment, Checklist and Flowcharts. Likewise, these are the most used in the construction industry (Uher and Toakley, 1999; Kloss-Grote and Moss, 2008; Chapman, 2001; Dey, 2001).

METHODOLOGY

The objective of this research is to verify the knowledge and implementation of risks identification techniques in construction companies in Rio de Janeiro State from the segments of the building sector, infrastructure and specialized services for construction, from the point of view of professionals working in them. The main aspect of this research is its focus on risk management applied to business rather than reliability and safety.

The research result was obtained by conducting a survey among professionals of construction companies, mostly in Rio de Janeiro. The survey followed the intersectional model, in which the application is performed at a single time (Bryman, 1989) (Babbie, 1999). In this case, considering the period from June to July 2010 and using a self-administered questionnaire with closed questions as a tool for data collection (Bryman, 1989; Babbie, 1999). It was distributed electronically via internet and data were analyzed using statistical techniques to draw a wide view of the construction sector instead of the companies individually. In addition, we used the simple random probability sampling to select elements of the sample, and the questionnaire was sent to all professionals who were included in the sampling frame.

The research sample could be characterized by same aspects, such as:

1. Sampling Element – Represented by Firms.
2. Sampling Universe - Represented by Construction Firms.
3. Sampling Population – Represented by Construction Firms from the segments Residential Housing Construction, Institutional and Commercial Building Construction, Specialized Industrial Construction, infrastructure and Heavy Construction.
4. Sampling Unit - As it was used a simple sample with a single stage, the sampling unit in this research is the same as the sampling element represented by the firms.
5. Sampling Frame - It was represented by two different lists. The first list was formed by construction firms from the Rio de Janeiro State Industrial Catalog - 2009/2010 edition published by the Federation of Industries of the State of Rio de Janeiro (FIRJAN) and the following classes / subclasses of Activity: 2513-6 - Heavy sheet metal works; 3011-3/01 - Construction of Large Vessels; 4110-7 - Real Estate Development; 4120-4 - Building Construction; 4212-0 - Construction of Special Bridges, Viaducts and Tunnels, 4292 -8 - Assembling of Industrial Installations and Metallic Structures; 4299-5/99 - Other Civil Engineering Works not specified before (FIRJAN, 2010).

The second list was formed by students of post-graduate courses offered by the laboratories of the School of Engineering of Federal Fluminense University (UFF), which develop activities for research and training in extension and specialized masters in the areas of design, construction, assembly, maintenance and inspection of equipment, and process plants. The courses / classes used were: Pipeline Engineering Specialization - Class 01, Specialization in Industrial and Manufacturing Mechanical Assembly - Classes 01, 02, 03, 04, 05, 06 and 07; Prominp - Specialization and Conditioning Commissioning - Classes 01 and 02; Prominp - Expertise in Construction Engineering and Construction Supplies - Classes 01 and 02; Prominp - Specialization in CM - Field Engineer - Construction and Assembly - Classes 01, 02, 03 and 04; Prominp - Projects Specialization Static Equipment - Class 01. These professionals worked in the construction industry of Rio de Janeiro State.

Moreover, the variables used in this study were qualitative. We used two of them to characterize the company and three to assess the risk management process. These variables used the ordinal Likert scale, often used in surveys (Babbie, 1999), and were composed of five (5) response categories that received the encoding 1-5.

The questionnaire was created and distributed through the web application tool Kwik Surveys (www.kwiksurveys.com) and was initially assessed in a pretest with three people, two of them professionals in the construction. The final version of the questionnaire was adjusted using the feedback received during the pretest. The distribution was realized by sending e-mails to addresses found in FIRJAN records, totalizing 709 (seven hundred and nine) emails. The list of emails obtained through UFF courses had 405 (four hundred and five) emails. Besides the original message with the invitation to participate in the survey, we sent seven reminders messages, getting the final 46 questionnaires.

Finally, frequency distributions and measures of central tendency of the data were generated with the help of the software Microsoft Excel (MS Excel) version for Windows 2007. For the correlation analysis, considering the scale of ordinal variables, we used Spearman's Rank Correlation Coefficient, based on non-parametric data, with the aid of GraphPad InStat version 3.05 for Windows 95/NT, GraphPad Software, San Diego, California, USA, www.graphpad.com.

RESULTS

Characteristics of the companies researched

The organizations surveyed were characterized by business sector and range of average annual gross revenue. Thus, Figures 1 and 2 show respectively the distribution of companies according to average annual gross revenue (R$ x 1,000) and the distribution of companies according to sector of activity. It is possible to observe then that about 2 / 3 (two thirds) of them stood on two main ranges of annual gross revenue, namely, between 5,000 and 350,000 (R$ x 1,000) and over 1 million (R$ x 1,000). Regarding the activity sector, over one half stood at two activities, Industrial and Assembly of Structural Steel and Other Civil Engineering Works not specified earlier.

Frequency of application and knowledge of risk identification techniques

The 18 identification techniques cited in literature were listed in the questionnaire to assess their frequency of use. Thus, the average frequency of use in Table 1 shows that the two risk identification techniques indicated as the most used were the Checklist and Root Cause Identification, and the two least used were Electronic Brainstorming and Synectics.

We also evaluated the amount of risk identification techniques known (Figure 3) and it was observed that the most informed professionals know from 3 (three) to 11 (eleven) identification techniques mentioned and that there were few extremes, that is to say that few people knew all the techniques or were completely or barely informed about them.

In turn, after analyzing a summary of the average frequency distribution of application of the risk identification techniques, we grouped the results by annual gross revenue ranges (Table 2) and found out that the range

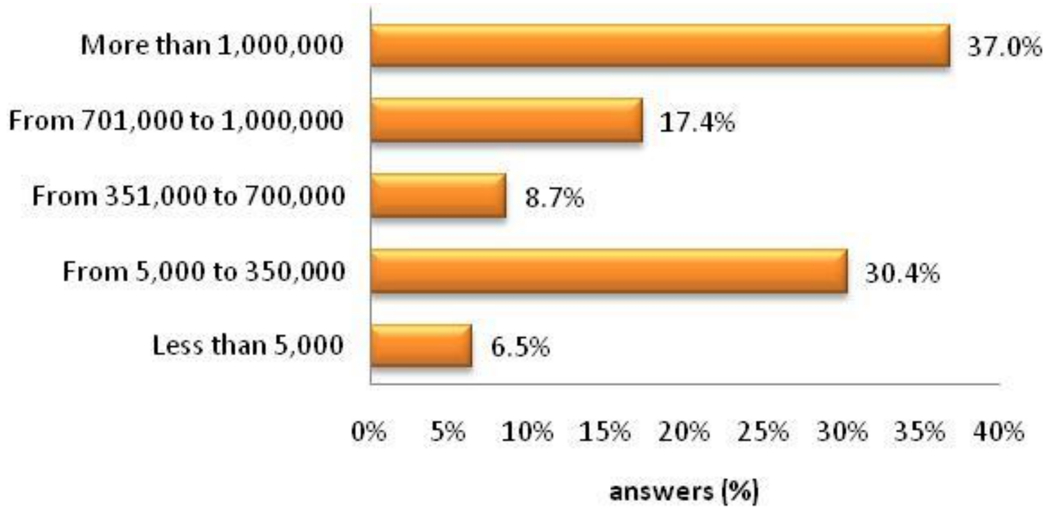

Figure 1. Arrangement of companies in accordance with the estimated annual gross revenue (R$ x 1,000).
Source: Martins, 2010, p.112.

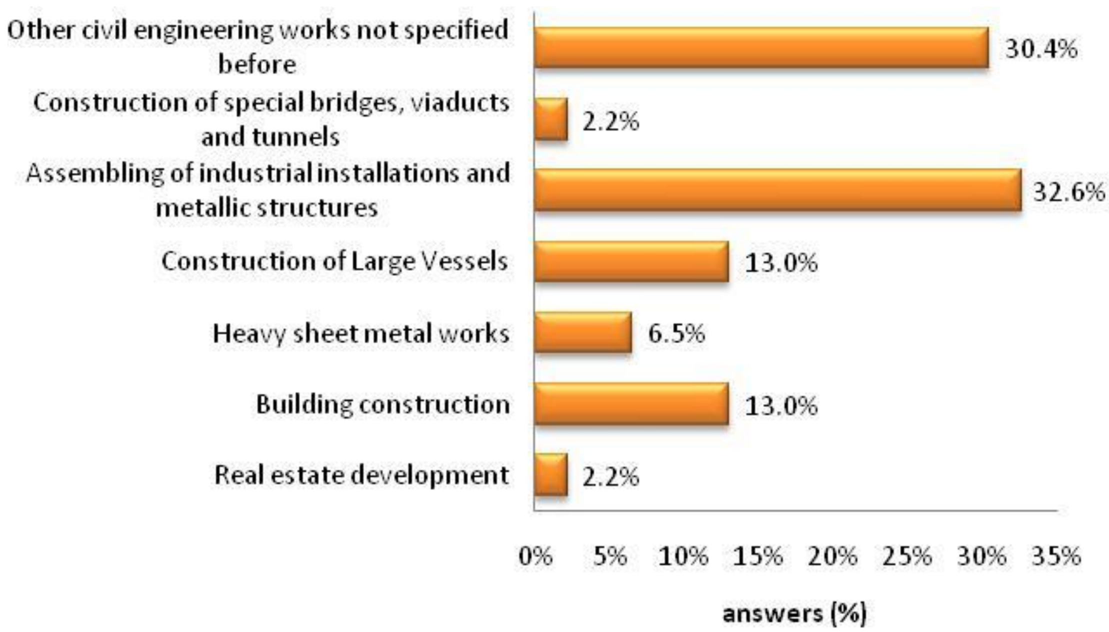

Figure 2. Arrangement of companies in accordance with the activities sector.
Source: Martins, 2010, p. 113.

of more than 1 million (R$ x 1,000) presented the highest average application.

After analyzing the amount of known identification techniques (Table 3). We observed that the knowledge of 16 techniques or more only occur between a little group of professionals from the companies in the highest gross revenue range. In contrast professionals working in organizations with lower gross revenue range showed little knowledge of techniques. Although, the best average knowledge belonged to professionals who worked in organizations in the range between 701,000 and 1,000,000 (R$ x 1,000).

Similarly, after analyzing the results grouped by sector (Table 4), we observed that the Real Estate Development sector presented the highest frequency of application of different techniques, if we did not consider their low representation. The sectors of Assembling of Industrial Installations and Metallic Structures and Heavy Sheet

Table 1. Average frequency distribution of application of the risk identification techniques by organization.

S/N	Risk Identification Techniques	Average	Ranking
1.	Brainstorming	3.02	(5)
2.	Delphi Technique	1.87	(15)
3.	Influence Diagram	2.26	(11)
4.	Interview/ Expert Judgment	2.98	(6)
5.	Checklist	3.70	(1)
6.	Nominal Group Technique	2.37	(10)
7.	Flow charts	3.13	(3)
8.	Scenario Building	3.07	(4)
9.	Pondering	1.96	(14)
10.	Root Cause Identification	3.22	(2)
11.	Cause-and-Effect Diagrams	2.91	(7)
12.	Questionnaire	2.78	(8)
13.	SWOT Analysis	2.17	(12)
14.	Synectics	1.85	(17)
15.	Case Based Approach	2.15	(13)
16.	Electronic Brainstorming	1.67	(18)
17.	What if? SWIFT structure	1.87	(16)
18.	Business Impact Analysis	2.76	(9)

Source: Martins, 2010, p. 201.

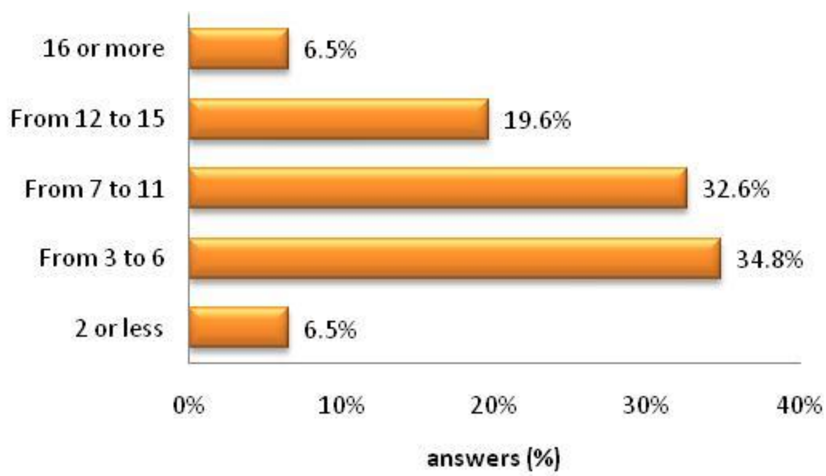

Figure 3. Distribution of the number of identification techniques known risks.
Source: Martins, 2010, p. 203.

Table 2. Summary of average frequency of application of the techniques of hazard identification for all tracks billing.

Risk identification techniques	Less than 5,000	From 5,000 to 350,000	From 351,000 to 700,000	From 701,000 to 1,000,000	More than 1,000,000
Brainstorming	2.33	2.14	2.75	3.50	3.71
Delphi technique	1.33	1.36	1.25	2.38	2.29
Influence diagram	1.33	2.36	1.25	2.63	2.41
Interview/Expert Judgment	1.67	2.36	3.00	3.13	3.65
Checklist	2.33	3.86	3.00	3.50	4.06
Nominal group technique	1.67	2.21	1.50	2.13	2.94
Flow charts	1.67	3.21	2.25	3.13	3.53

Table 2. Contd.

Scenario building	1.67	2.64	1.75	3.50	3.76
Pondering	1.67	1.50	1.50	1.75	2.59
Root cause identification	3.67	2.86	2.00	3.25	3.71
Cause-and-effect diagrams	1.67	2.64	1.75	3.25	3.47
Questionnaire	1.67	2.71	2.25	2.75	3.18
SWOT analysis	1.33	1.71	1.75	2.63	2.59
Synectics	1.33	1.57	1.50	1.75	2.29
Case Based approach	1.33	2.07	1.75	2.13	2.47
Electronic brainstorming	1.33	1.57	1.50	2.25	1.59
What if? SWIFT structure	1.33	1.64	1.50	2.25	2.06
Business impact analysis	2.33	2.86	1.75	3.00	2.88

Source: Martins. 2010. p. 214.

Table 3. Summary of the amount of risk identification techniques known companies by revenue band.

Range	≤ 2 (%)	From 3 to 6 (%)	From 7 to 11 (%)	From 12 to 15 (%)	≥ 16 (%)
Less than 5,000	66.7	33.3	0.0	0.0	0.0
From 5,000 to 350,000	0.0	42.9	28.6	28.6	0.0
From 351,000 to 700,000	25.0	75.0	0.0	0.0	0.0
From 701,000 to 1,000,000	0.0	25.0	25.0	50.0	0.0
More than 1,000,000	0.0	23.5	52.9	5.9	17.6

Source: Martins. 2010. p. 215.

Table 4. Summary of average frequency of application of the risk identification techniques for all sectors of activity.

Risk identification techniques	Real estate development	Buildings construction	Heavy sheet metal works	Construction of large vessels	Assembly industrial installations and metallic structures	Construction of special bridges, viaducts and tunnels	Others civil engineering works not specified before
Brainstorming	5.00	2.00	3.33	2.33	3.53	5.00	2.86
Delphi technique	5.00	1.50	1.67	1.83	2.27	1.00	1.50
Influence diagram	5.00	3.17	2.00	2.50	2.20	2.00	1.71
Interview/expert judgment	5.00	3.33	3.33	2.83	3.00	5.00	2.50
Checklist	5.00	3.67	4.00	3.50	3.93	4.00	3.36
Nominal group technique	5.00	2.50	2.33	2.00	2.60	3.00	2.00
Flow charts	5.00	4.33	3.00	3.50	3.20	2.00	2.36
Scenario building	5.00	3.17	3.67	2.83	3.40	4.00	2.43
Pondering	5.00	2.00	1.67	1.50	2.40	1.00	1.57
Root cause identification	5.00	3.50	4.33	2.83	3.33	4.00	2.71
Cause-and-effect diagrams	5.00	2.83	2.67	3.17	3.27	2.00	2.43
Questionnaire	1.00	2.50	3.00	2.67	3.13	3.00	2.64

Table 4. Contd.

SWOT analysis	1.00	2.33	1.67	1.67	2.87	2.00	1.79
Synectics	5.00	2.17	1.67	1.50	2.07	1.00	1.50
Case based approach	1.00	2.17	2.67	1.83	2.47	2.00	1.93
Electronic brainstorming	1.00	1.67	2.67	1.83	1.73	1.00	1.43
What if? SWIFT structure	1.00	1.67	2.33	2.00	2.27	1.00	1.50
Business impact analysis	5.00	3.33	4.00	2.17	2.87	1.00	2.36

Source: Martins. 2010. p. 234.

Table 5. Summary of frequency of use for organizing of risks identification techniques to all sectors of activity.

Sectors	≤ 2 (%)	From 3 to 6(%)	From 7 to 11 (%)	From 12 to 15 (%)	≥ 16 (%)
Real estate developments	0.0	0.0	0.0	100.0	0.0
Buildings Construction	0.0	33.3	16.7	50.0	0.0
Heavy sheet metal works	0.0	33.3	66.7	0.0	0.0
Construction of large vessels	0.0	33.3	33.3	16.7	16.7
Assembly Industrial Installations and Metallic Structures	0.0	40.0	40.0	20.0	0.0
Construction of special Bridges, Viaducts and Tunnels	0.0	0.0	100.0	0.0	0.0
Others civil engineering works not specified before	21.4	35.7	21.4	7.1	14.3

Source: Martins. 2010. p. 235.

Metal Works would actually have presented the highest frequencies of application. In turn concerning the quantity of known techniques (Table 5). We observed that responses that fit the range of knowledge of techniques from 7 to 11 were the most widely distributed among all sectors. Nevertheless only practitioners of Construction of Large Vessels and Other Civil Engineering Works Not Specified Before to some extent claimed to know all or almost all the techniques.

Finally, we sought to examine if there was any correlation between the frequency of use of each of the risk identification techniques and the formalization of risk management. Therefore, Table 6 presents the results of this correlation. in which it is possible to observe that 14 (fourteen) techniques showed a moderate positive correlation with the formalization of risk management, whereas 4 (four) showed a weak positive correlation. Moreover, the values of “p-value” ranged from significant to extremely significant. Taking these points into account, we concluded that the formalization of risk management in the organizations may be directly related to the increase in the frequency of application of these techniques.

DISCUSSION

As a consequence, we can see a partial correspondence between the results and the literature since, from the 5 (five) most cited techniques presented in Table 1, only the Delphi Technique and Influence Diagram did not appear in the survey among the most used, result either grouped by annual gross revenue ranges or activity sector. In fact, the techniques mentioned in literature as the most used in the construction area were Brainstorming. Interview / Expert Judgment, Checklist and Flowchart (Uher and Toakley, 1999; Kloss-Grote and Moss, 2008; Chapman, 2001; Dey, 2001). Therefore, the research result accords with literature in the extent that 3 (three) of them appeared among the five (5) techniques that presented the greatest frequency of application where Checklist technique was even identified as the most used. However, when we grouped the organizations by annual gross revenue and sector the following techniques emerged as the most used: Root Cause Identification, Checklist, Interview / Expert Judgment, Brainstorming, Creation of Scenarios and Flowchart, where Checklist appeared most frequently.

In turn if we compare the five techniques mentioned in literature with the ones we identified as those with lowest average frequency of use, we observe that, while the literature indicates Business Analysis Impact Technique and Case-Based Approach, our research points out Delphi Technique and Pondering as least used instead. However, taking into account the annual gross revenue and sector ranges, the techniques that appeared most

Table 6. Correlation between the frequency of application of risk identification techniques and formalization of risk management.

Risk identification techniques	ρ	*p-value*	Confidence interval (95%)
Brainstorming	0.4583	0.0014	[0.1852 ; 0.6657]
Delphi Technique	0.5256	0.0002	[0.2694 ; 0.7123]
Influence Diagram	0.4675	0.0011	[0.1965 ; 0.6721]
Interview/Expert Judgment	0.4436	0.0020	[0.1674 ; 0.6553]
Checklist	0.4265	0.0031	[0.1468 ; 0.6431]
Nominal Group Technique	0.4784	0.0008	[0.2100 ; 0.6798]
Flow charts	0.4746	0.0009	[0.2052 ; 0.6771]
Scenario Building	0.5185	0.0002	[0.2603 ; 0.7075]
Pondering	0.4429	0.0021	[0.1665 ; 0.6548]
Root Cause Identification	0.5499	< 0.0001	[0.3008 ; 0.7287]
Cause-and-Effect Diagrams	0.4390	0.0023	[0.1617 ; 0.6520]
Questionnaire	0.3443	0.0191	[0.05113 ; 0.5829]
SWOT Analysis	0.5678	< 0.0001	[0.3243 ; 0.7407]
Synectics	0.4070	0.0050	[0.1236 ; 0.6290]
Case Based Approach	0.3371	0.0220	[0.04297 ; 0.5774]
Electronic Brainstorming	0.3068	0.0381	[0.009196 ; 0.5545]
What if? SWIFT structure	0.4450	0.0019	[0.1690 ; 0.6563]
Business Impact Analysis	0.3234	0.0284	[0.02760 ; 0.5671]

Source: Martins. 2010. p. 236.

frequently as those with lower average application were Electronic Brainstorming, Delphi technique and Synectics. On the other hand, the results showed that approximately 73% of participants demonstrated to know 11 techniques.

Conclusion

The survey showed that the risk identification technique called Checklist is the most often used, followed by Flowchart and Brainstorming. This result aligns with the list of identification techniques described in literature as the most commonly used in construction. However, it is interesting to note the exclusion of Brainstorming technique and Interview / Expert Judgment in the lists of the techniques most commonly used when analyzing by annual gross revenue range or activity sector since they are also considered by literature as the most popular.

Another interesting point to note is that the Delphi Technique was identified by us as one of the least used, while in literature it is frequently mentioned.

In addition, it is clear that among the participants there is not an overall knowledge of the techniques described in literature as possible to be applied to identify risks. This situation certainly influences the application of these techniques. Nevertheless, it is understandable that the knowledge of these techniques does not guarantee that they will be applied by the organizations, which will choose what they consider the most familiar and reliable techniques.

Finally, although we can find other researches on risk management in Brazil, the number of studies in this field remains insufficient, especially in construction. Indeed there is a lot of opportunity to promote the use of risk management in organizations and the employment of the risk identification techniques.

REFERENCES

Adler TR, Leonard JG, Nordgren RK (1999). Improving risk management: moving from risk elimination to risk avoidance. Inform. Softw. Technol., 41: 29-34.

Akintoye AS, Macleod M (1997). Risk analysis and Management in construction. Int. J. Project Manag., 15 (1): 31- 38.

Al-Bahar JF (1988). Risk Management In Construction Projects: A Systematic Analytical Approach For Contractors, Dissertation, The University of California at Berkeley, Department of Civil Engineering, Construction Engineering and Management.

Association for Project Management (APM) (2000). Project Management Body of Knowledge. 4th ed. United Kingdom.

Babbie E (1999). Métodos de Pesquisas de Survey. Tradução Guilherme Cezarino. Belo Horizonte: Ed. UFMG. Pp.519.

Baccarini D (2001). Risk Management Australian Style – Theory vs. Practice. In:Project Management Institute Annual Seminars & Symposium; 2001 Nov 1-10; Nashville. Tennessee. USA.

Birch DGW, McEvoy MA (1992). Risk analysis for information systems. J. Inform. Technol., 7: 44-53.

Bryman A (1989). Research Methods and Organization Studies. Great Britain: Routledge. pp. 283.

Bufaied A S (1987). Risks in the Construction Industry: their Causes and their Effects at the Project Level. Thesis (Ph.D) - University of Manchester, UMIST.

Chapman C, Ward S (2003). Project Risk Management: Processes.

Techniques and Insights. 2nd ed. West Sussex. England.
Chapman RJ (1998). The Effectiveness of Working Group Risk Identification and Assessment Techniques. Int. J. Project Manag., 16(6): 333-343.
Chapman RJ (2001). The controlling influences on effective risk identification and assessment for construction design management. Int. J. Project Manage., 19(3) 147-160.
Dey PK (2001). Decision support system for risk management: a case study. Manage. Decis., 39(8) 634-649.
Edwards PJ, Bowen PA (1998). Risk and risk management in construction: a review and future directions for research. Eng. Constr. Archit. Manage., 5(4): 339-349.
Federação Das Indústrias Do Estado Do Rio De Janeiro (FIRJAN) (2010). Cadastro Industrial do Estado do Rio de Janeiro 2009/2010. Rio de Janeiro: Ed. EBGE. 1 CD-ROM.
Ferreira MLR (2009). Gerenciamento de Risco. Apresentação de Aula. Universidade Federal Fluminense – Programa de Pós-Graduação em Engenharia Civil.
Ghani JA (2005). Construction Risk Management. Punjab Information Technology Board. 6 jun. 2005. Disponível em: <http://www.pitb.gov.pk/downloads.aspx>. Acesso em: 2 mai. 2009.
Ghani JA (2009) Construction Risk Management. Punjab Information Technology Board. June 6, 2005. Retrieved May 2, 2009 from http://www.pitb.gov.pk/downloads.aspx.
International Electrotechnical Commission/International Organization for Standardization (IEC/ISO) (2009). IEC/ISO 31010 Risk Management – Risk assessment techniques. 1st ed. Switzerland, pp. 38, 42.
International Organization for Standardization (ISO) (2009). ISO 31000 Risk Management – Principles and guidelines. 1st ed. Switzerland.
Investopedia ULC (2010). Financial Dictionary. Disponível em: <http://www.investopedia.com/dictionary/>. Acesso em: 18 out. 2010.
Jaafari A (2001). Management of risks, uncertainties and opportunities on projects: time for a fundamental shift. Int. J. Project Manag., 19: 89-101.
Kerzner H (2001). Project Management: a systems approach to planning, scheduling, and controlling. United States: John Wiley & Sons.
Kloss-Grote B, Moss M (2008). How to measure the effectiveness of risk management in engineering design projects? Presentation of RMPASS: a new method for assessing risk management performance and the impact of knowledge management – including a few results. Research in Engineering Design, 19(2/3):71-100.
Lapponi JC (2000). Projetos de Investimento. São Paulo: Lapponi Treinamento e Editora, pp. 378.
Limmer CV (1997). Planejamento, Orçamentação e Controle de Projetos e Obras. Rio de Janeiro: Livros Técnicos e Científicos, pp. 225.
Martins CG (2006). Aplicação das Técnicas de Identificação de Risco em Projetos de E & P. 2006. 93f. Monografia (Pós-Graduação - MBA em Engenharia Econômica e Financeira) – Universidade Federal Fluminense – UFF. Niterói.
Martins CG (2010). Avaliação da Função Utilidade do Segmento da Construção e seu Grau de Conhecimento do Processo de Gerenciamento de Riscos e das Técnicas de Identificação e Análise. 2010. 333 f. Dissertação (Mestrado em Engenharia Civil) – Universidade Federal Fluminense – UFF. Niterói.
Max W (ed) (1992), R. Project and Program Risk Management: A Guide to Managing Project Risks and Opportunities. USA: Project Management Institute.
Morano CAR (2003). Application of Risk Analysis Techniques in Construction Projects. 2003. 206 f. Dissertation (Master in Civil Engineering) - Universidade Federal Fluminense - UFF. Niteroi.
Morano CAR, Martins CG, Ferreira MLR (2006). Application of techniques for the identification of risk in the E & P ventures Engevista., 8(2):120-133.
Öztaş. A, Ökmen Ö (2005). Judgemental risk analysis process developement in construction projects. Build. Environ., 40:1244-1254.
Porter CE (1981). Risk Allowance in Construction Contracts M.Sc. Thesis, University of Manchester, UMIST.
Pritchard CL (1996). Risk Management – Concepts and Guidance. Virginia: ESI International, pp. 218.
Project Management Institute (PMI) (2008). A Guide to the Project Management Body of Knowledge: PMBOK Guide. 4thed. Pennsylvania. USA.
Raftery J (1994). Risk Analysis in project management. 1st ed. Great Britain: E & FN SPON.
Rowe WD (1977). An anatomy of risk. New York: Wiley.
Royal Society (1991). Report of the Study Group on Risk: Analysis, Perception, and Management (group co-ordinator Sir F. Warner). Royal Society, London.
Shen LY (1997). Project risk management in Hong Kong. International J. Project Manage., 15(2):101-105.
Uher TE, Toakley AR (1999). Risk management in the conceptual phase of a project. Int. J. Project Manage., 17(3):161-169.
Valeriano DL (2001). Gerenciamento Estratégico e Administração por Projetos. São Paulo: Makron Books, pp. 295.
Wright JTC, Giovinazzo RA (2000). DELPHI – Uma ferramenta de apoio ao planejamento prospectivo. Caderno de Pesquisas em Administração. São Paulo, 1(12).
Zeng JANM, Smith NJ (2007). Application of a fuzzy based decision making methodology to construction project risk assessment. Int. J. Project Manage., 25:589-600.
Zou PXW, Zhang G, Wang J (2007). Understanding the key risks in construction projects in China. Int. J. Project Manage., 25:601-614.