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ENTERPRISE RISK MANAGEMENT AND MANAGERIAL RISK PERCEPTION: AN ANALYSIS THROUGH EYE TRACKING EXPERIMENTS

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ABSTRACT

This paper deals with the analysis of the importance of ERM's role in companies today, by analyzing how to create and carry out this process and how it can bring benefits to the entire corporate environment.

The structure is divided in two Macro-Areas:

1. ERM and Risk Matrix Approach
2. Eyetracking and Managerial Risk Perception experiment

More specifically, through the first part, the author analyzes the fundamental components that form an ERM process and decisions. Through these analyses, the reader is able to see what kind of advantages and disadvantages of implementing such a strategic line may occur. A Focus on the various steps necessary for its creation will be also shown.

At the end of the first part the most common risk identification and evaluation techniques are illustrated.

Through second part of the paper, a more experimental risk management analysis is carried out with a particular focus on managerial risk perception.

Initially, there is an analysis of how human behavior is influenced in risk perception when uncertain situation occurs, through the introduction of study branches such as Behavioral Account Research and Neuroaccounting. Turning attention to a more practical study, the analysis will then focus on the results analysis of author's experiments through eye tracking technology. Using this tool, the author has set up an experiment consisting in studying individuals' visual reactions to specific risk situations. The experiment output data will be further discussed later on.

PREFACE

Management risk perception studies have a relevant starting point: the risk concept.

Risk is: *A probability or threat of damage, injury, liability, loss, or any other negative occurrence that is caused by external or internal vulnerabilities, and that may be avoided through preemptive action*[47].

Usually this damage is predictable, but either the occurrence or the amount of damage it can cause are not certain.

It is extremely important managing risks to contain the loss of "business amenity". To do this, we need to understand what is the right way to identify, measure and understand risks [31].

The definition of risk involves two key aspects:

- Quantitative
- Qualitative

Regarding the qualitative ones, risk can be read as *upside risk* ("uncertain possibility of gain[48]") or *downside risk* ("risk of the actual return being below the expected return, or the uncertainty about the magnitude of that difference[49]"). In quantitative terms, however, the risk can be identified as a unit of measurement in terms of quantification of the loss expectation [31].

If the concept of risk typically has a negative value, it becomes important to try to manage it to be able to take advantage from positive opportunities. This aspect is strongly linked to the individual attitude. In fact, people can be *risk-averse* or

risk-taking. Moreover, this attitude could change switching from different business areas/situations.

This is the reason why is important studying managerial risk perception to strengthen risk management strategies and try to optimize them.

Risk management leads to the comprehension of three important guidelines:

1. What kind of risk is acceptable and how to handle it.
2. Which risk must be avoided and how.
3. What risk can be predicted and how to manage it.

These understandings require the definition of a *risk tolerance range*: the risk tolerance for an account should reflect the amount of risk individuals are comfortable with [31]. In other terms, business people must choose a range in which risk can be altered without significant impact.

Once the tolerable risk is settled, the residual risk will be managed with a dedicated hedging strategy [31]. This strategy will try to undertake all the *upside risk* and everything else will be handled through specific business policies.

The risks that threaten an organization and its management may have originated from factors both external and internal to it (see *Fig. 1*) [21]. The diagram overleaf summarizes examples of key risks in these areas and shows how certain types of risks are likely to have stimulation factors both external and internal, and then

occupy both areas [21]. You can further distinguish the types of risks, for example strategic, financial, operational, and so on.

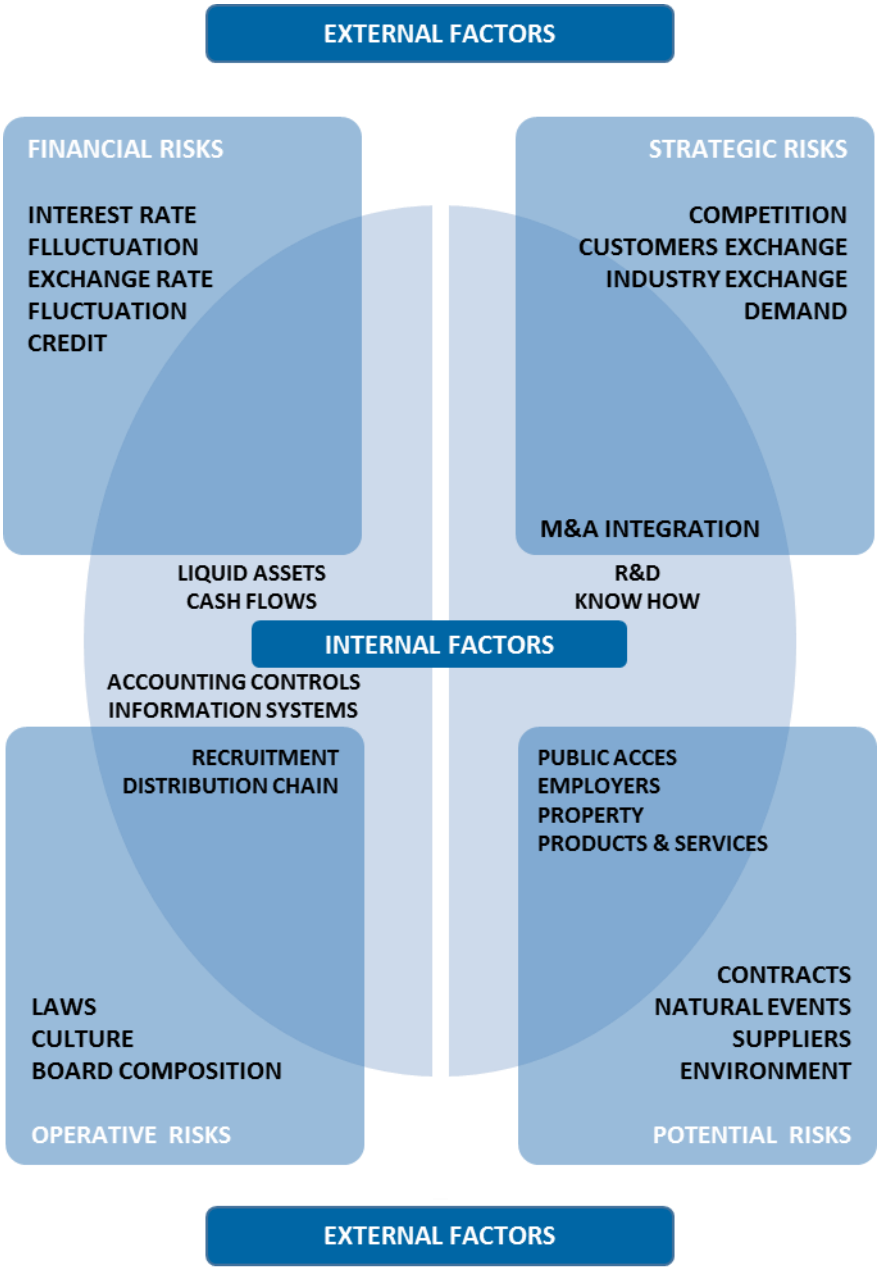


Fig. 1 - This figure illustrates the factors of stimulation of main risks affecting the company[21].

As previously mentioned, risks can be categorized according to multiple taxonomies depending on needs and the core business of the company. In this case, are explained:

- *Financial risks*, such as fluctuations in interest
- *Potential risks*, for example, other natural events that can affect business
- *Strategic risk*, eg, customer changes
- *Operational risks*, for example, new hires

CHAPTER I

ENTERPRISE RISK MANAGEMENT AND RISK MATRIX APPROACH

Over the years the importance of risk management has been increasing more and more.

Initially considered to be a function that is not strictly necessary for the company, today the function of enterprise risk management is a key part of the structure of the enterprise, participating actively to the creation of value.

Every day businesses are facing risks related to almost every single action carried out within the business context.

Through the process of ERM the company is able to better identify risks arising from their activity and implement the best strategies to deal with them and use them to create value. Being able to make a clear separation between what can be called "good risk" and what can be considered "bad risk", the top management of enterprises is able to align business objectives with the level of risk that decides to choose, to maximize the benefits derived from this process and minimize adverse effects.

As well as over the years has increased the importance attributed to this corporate function, likewise has increased the complexity of the underlying processes to it.

Risk management systems require the implementation of several steps, each of these requires the execution of an effective and efficient management. The implementation of each step implies that the company have to use a significant amount of resources, mostly intangible, precisely proportional to the importance that the ERM are taking within business contexts. That is why more and more efficient and innovative ways are searched for the implementation of these

processes, so as to maximize the potential of this business area and minimize adverse effects.

A more detailed explanation is provided in the following pages, offering an understanding of the complexity and the importance of ERM processes within modern enterprises.

1.1 *From Risk Management to ERM*

Fifty years ago, business people used to interpret Risk Management as the need to avoid risks. Year on year, Risk Management has been recognized as a complex task that requires the identification, measurement and the definition of strategy management[9].

Managers realized the more a company can define a risk management program, the more managers can save time and optimize business strategies[23].

It is also clear that this activity allows managers to have greater knowledge and great control over the company's performance[15].

The presence of all these benefits sparked the development of risk management.

For many years, risk management function was a separate and independent entity within the company, which used to have a marginal impact on the company's core business[31]. Over time, however, some of standard risk approaches' limits have been recognized. The first of these limits was the *separation of risk stewardship*: this attitude caused inefficiencies due to the higher costs and results scarcity. This led business people realize the need to adopt a homogeneous risk management approach: the so called *integrated management*[15].

Through this method, the whole business functions feel the need to evaluate the risk and to monitor key risk indicators[31].

In the past, each business unit used to work alone, without being in communication one another[31]. The stark division of tasks that was created, did

not consider interrelations and interdependencies between risks of different areas, creating a lack of coordination between functions as well as an inefficient cash management.

After the separation of different risks management, the second negative aspect (that is quite still present today), was taking into consideration just *down-side risks*: potential positive gains were not considered at all(31). This was also influenced by the level of *risk aversion* of each individual.

However, it's possible to evaluate benefits that can be obtained from the risk management. This aspect has been included in the ERM view, that seeks to exploit opportunities from risk and not just to eliminate it, trying to resize at the same time the negative effects of risk.

Segal states that ERM is:

"*The process by which companies identify, measure, manage and disclose all key risks to increase to value to stakeholders*"(30)

This is a general definition that does not allow to highlight some crucial aspects of the integrated management(31). In fact, it emphasizes only the phases characterizing risk management that are common to all the types of risk management models.

The Committee of Sponsoring Organizations of the Treadway Commission[1] states in a more specific view:

[1] The Committee of Sponsoring Organizations of the Treadway Commission (COSO) is a joint initiative of the five private sector organizations listed on the left and is dedicated to providing thought leadership through the development of frameworks and guidance on enterprise risk management, internal control and fraud deterrence (*www.coso.org*).

"Enterprise risk management is a process, effected by an entity's board of directors, management and other personnel, applied in strategy setting and across the enterprise, designed to identify potential events that may affect the entity, and manage risks to be within its risk appetite, to provide reasonable assurance on the achievement of entity objectives[13]"

From this definition, we can understand the concept of integration across business functions and areas, that involves the whole company and is recognized as a key aspect in helping companies achieving its goals to gain a competitive advantage.

1.2 *ERM Development in Italian companies*

Nowadays has become important that companies, especially the largest and listed companies, have an adequate level of protection against risks within their business areas.

The development of risk governance systems, the empowerment at all levels of the company, safeguarding the reputation in the market, the legislative and regulatory framework, represent some of the main reasons that have pushed, or instituting, Italian companies to invest more and more in risk management systems[19].

However, the Italian situation today proves that the concept of Risk Management is not yet widely shared by corporate management, especially in medium-small firms.

Due to high costs and organizational difficulties, small businesses often decide not to use risk management systems.

Regulatory obligations seem to have little influence on the decision to initiate risk management processes: corporate executives prefer to implement structured risk management processes due to expected benefits such as defending corporate reputation, value creation, or losses reduction rather than requirements for mere compliance, preferring economic benefit rather than adapting to regulation. [27].

A survey conducted by KPMG shows which are the main reasons that led Italian companies to introduce ERM processes.

About half of the respondents argue that the process should be introduced to increase the responsibility of risk management in all company departments[27].

The majority of respondents has launched projects in this direction even though many companies are still at the preliminary stages of implementing a real process

of ERM, proving that much remains to be done in terms of design and adoption of an integrated model of risk management.

The most widespread risk management model in the Italian context (68%) envisages the centralization of risk management policies and the decentralization of operational management at business unit / divisional level in line with strategic guidelines: onnly in very few cases (5%), the risk management policies are defined, implemented and managed independently by the enterprise business unit without the involvement of top management. [27].

Despite the fact that the ERM model is not fully exploited by Italian companies, more than 90% of responding companies have executed at least one risk assessments, identifying the main risks that concern management and threatening business goals. [27].

Observing the risks portfolio, as outlined by respondents, is shown that market risks, credit and reputation are the main concerns of the Italian management, perhaps influenced by the current economic situation[27].

The analysis shows that risks perceived as most critics are most effectively managed, with a greater use of qualitative techniques, albeit slightly, to quantitative ones.

The final results of the study confirm that risk management is going to be important for firms, but that still takes its first steps[27].

The benefits of the ERM are real and measurable in some cases, this is shown by the responses of the top management of the Italian companies.

Value creation and protection of reputation are identified as key benefits and represent, in fact, the main reasons for the implementation of the ERM process; anyway, the main obstacles to introducing and developing the process continue to exist, emerging out of all the lack of time and resources[19].

1.3 *ERM Limits*

The Enterprise Risk management can only provide a reasonable assurance on the achievement of corporate objectives.

Therefore, if on the one hand allows people to get important benefits, on the other hand it also has limits. The latters are determined by wrong choices, from simple malfunctions or errors.

In addition, controls can be outweighed by the collusion of two or more people and the capacity of management to circumvent the process of risk management, including decisions to respond to risk and control activities.

These limits prevent the Board of Directors and managers to have absolute certainty in relation to the corporate goals(14).

In considering the limits of Enterprise Risk Management will have to bear in mind three concepts:

- The risk concerns a future and uncertain event
- ERM, although adequate, operates at different levels in relation to the various categories of objectives. As regards the strategic and operational objectives, this process can only help the management and Board of Directors to learn whether or not the company is directed towards those objectives, but cannot provide any assurance that the same objectives will be achieved(14);
- ERM cannot provide absolute security against any of the categories of objectives;

Please note, however, that the expression "*reasonable assurance*" does not imply that the ERM will be frequently ineffective or inappropriate but people should be aware that an effective Enterprise Risk Management process can be, in some cases, unfit for its purpose(19).

We find limit of ERM also in all decisions that are taken by the single individual in the business context, that are influenced by people judgment and personality.

It's easy to say that the Enterprise Risk Management process might fail.

In addition, it may be the case that the risk management process may spread in enterprise a climate of obsession with risk control[19]. The Enterprise Risk Management can induce managers to work under voltage with the idea fixes to continuously controls, resulting in side effects and negative consequences for the company[19]. Companies must take into account the cost-benefit ratio when they decide to enable decisions, including those concerning the response to risk and control activities. When people decide to activate a particular intervention or to introduce some degree of control, they need to consider the risk of failure and the potential effect on the company, even in terms of costs.

We can say that the Enterprise Risk Management process depends on people: it is as effective as those responsible for implementing it.

Even companies are well managed and controlled, a manager may be able to avoid the ERM. Actions to circumvent the risk management process are not documented and are carried out with the intention of concealing the actions themselves.

These limitations listed, do not allow the Board of Directors and management to achieve absolute security on the achievement of business goals, but thanks to the total effect of the responses to the risk, it can reduce the chances that the company will miss its goals[19].

1.4 *Enterprise Risk Management and managerial risk profiling*

The purpose of any risk management system is not the complete elimination of risks.

Business activity is indissolubly connected with the uncertainty: the main purpose of risk management should be evaluating and managing risks to achieve results(34).

Risk-taking should be evaluated, not only in the light of an individual analysis of the single random event, but always considering the coherence between the company's overall risk and the desired risk profile.

The main purpose of the ERM is identified in achieving business goals, evaluating risks and the subsequent management of those that the company chooses to undertake. The choice of the firm risk profile is strongly related to the achievement of business goals.

This level, also known as *tolerable risk*, assumes a crucial value, as all business decisions are influenced by this parameter: the selection of an adequate risk level is based on various evaluations regarding the company, its activities, the importance of the different stakeholders and other factors(34).

The chosen tolerable risk must be the result of a meeting between the summits of the firm, because it will affect both the strategic choices addressed by the board and the operational ones, regarding the attitudes of the executives of the various units; we can consider this procedure the starting point for future strategic decisions, as well as for the allocation of resources among the different divisions(34).

The main task of the ERM is to identify well suited strategies to the acceptable risk, discarding the ones that are deemed unsuitable due to the excessive risk in achieving the predefined profitability targets(34).

No risk management system can guarantee complete certainty of goals achievement: it purpose is to help reaching them with a degree of reasonable certainty. This reasonableness may, in fact, be determined in a very different way, depending on a large set of different variables.

Such confidence threshold is also defined *risk tolerance*, a term which indicates the degree of variability in investment returns that an investor is willing to withstand[52].

Once found the acceptable risk and risk tolerance, the ERM system is a useful tool to align strategies and risks. The goals that integrated risk management are intended to help achieving are divided into the CoSO framework in four categories[13]:

- ***Strategic goals***

  Strategic objectives are generally based on the company's mission. These objectives are planned to be permanent, having to represent the starting points of a company's activities. These goals should highlight the ways for the company to create value for its stakeholders and are usually outlined to be consistent over time[29].

- ***Operational goals***

  This category represents short and medium term goals related to the business operative unit's activities. Their main purpose is usually to achieve adequate levels of performance throughout the company. The importance of operational targets resides in their leading role in the decision-making process about the use of resources, because incorrect choice of these can generate a huge waste of resources

- ***Reporting goals***

  These goals address the availability of accurate, timely information and its consistence with the prearranged objectives. The importance of achieving these objectives arises from the fact that the reports represent the fundamental information on which management bases its decisions and it represent also the first tool that can be spread to stakeholders. Publicly available documents such as financial statements, accompanying notes and statements are, in fact, an integral part of the image that outsiders have of the company(34).

- ***Compliance goals***

  Each country has its own legislative system that, if not respected, can result in direct losses, such as penalties for each company. The compliance goals determine operating policies and procedures that should be implemented to ensure compliance with regulatory requirements and these are also mainly dependent on the company's organizational structure and, consequently, the adoption of an effective ERM system is a way of ensuring their achievement(34).

Otherwise, achieving strategic and operational goals can be influenced by more elements that are not under the company's control. In these areas, integrated risk management can only inform management and the board of directors of the existence and magnitude of such risks.

1.5 *ERM Journey*

The enterprise risk management process protects and gives value to the Organization and its stakeholders, supporting the Organization's objectives with[17]:

- Preparation of a methodological framework which allows one unfolding and checked by any future activities
- Improving decision-making, planning and setting of priorities through a comprehensive and structured understanding of business activity, volatility and positive/negative elements of the project
- Support for a more effective utilization/allocation of capital and resources within your organization
- The reduction in non-essential areas of volatility report corporate protection and enhancement of heritage and corporate image
- Development and support of the people and the knowledge base of the Organization
- Optimizing operational efficiency

The figure below shows the Risk Management logical thread, whose overall aim is minimizing the potential impact of the risks associated with the Organization and business model objectives and stakeholder value creation and defense strategies[11].

***Fig. 2** - Risk Management logical thread*[11].

It is important to understand that the process of managing each risk goes through these steps at least once and often cycles through numerous times[36]. Also, each risk has its own timeline, so multiple risks might be in each step at any point in time[36].

The ERM process can be divided into the following steps:

1. Strategy and Risk appetite definition.
2. Risk assessment, starting from risk identification.
3. Reporting on the risk assessment's results.
4. Risk treatment.
5. Assessment and reporting on residual risks.
6. Continuous risk monitoring.

Each step will be shown and explained thought the next paragraphs.

1.5.1 *Strategy and Risk appetite definition*

Adhering to proactive risk management, the ERM process interacts with strategic planning processes, supporting additional investing and financing decisions within the company, thus helping to identify strategic alternatives that are consistent with the Stakeholder risk perception[17].

After identifying strategic, high-level objectives, the company should think about managing risks inherent its business, maximizing the likelihood of positive outcomes and minimizing the risk of losses: it is necessary to define a risk management plan that is functional in achieving strategic goals[17].

Each enterprise need to design a specific strategic line considering the different types of risk, the resources to involve into ERM activities, the process structuring, and how to evaluate and treat risks.

Concurrently with the definition of the objectives, the company should define the so-called *Risk Appetite*, that is defined as:

"The amount and type of risk that an organization is willing to take in order to meet their strategic objectives. Organizations will have different risk appetites depending on their sector, culture and objectives. A range of appetites exist for different risks and these may change over time[50]"

In other words, *Risk Appetite* is the amount of overall risk that the company is willing to take within the limits imposed by its risk capacity, in achieving the goals of business value growth.

The *Risk Appetite* is defined according to the stakeholder expectations and it reflects the company's propensity to risk, which in turn influences the growth strategies of value and the adopted business model. One of the key aspects is therefore the full integration of risk appetite within the process of defining and implementing the corporate strategy, because this fact allows the identification of strategic objectives in coherence with the desired risk/performance index, useful tool to guide risk management activities inside the company[17].

The *Risk Appetite Statement* is a document that express the propensity of the company to be exposed to risks, showing ERM Policy for every firm (See *Figure 3*). This propensity will be extended to the whole organization and it is formulated by considering the different expectations of the stakeholders and all the significant risks involved in conducting the business[17].

"*The risk appetite statement is generally considered the hardest part of any enterprise risk management implementation. However, without clearly defined, measurable tolerances the whole risk cycle and any risk framework is arguably at a halt*[38]".

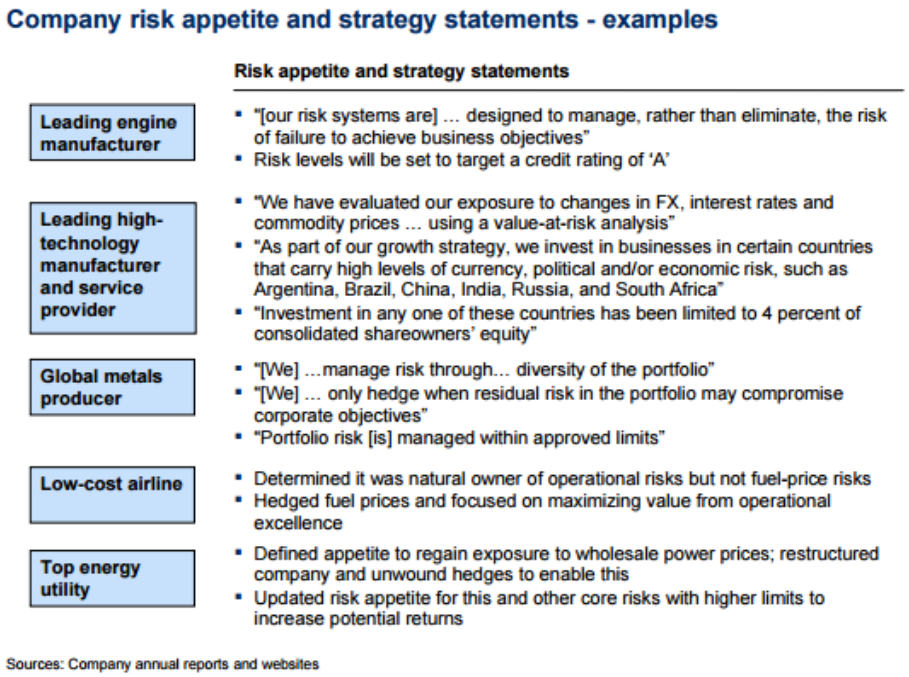


Fig. 3 *– Example of a Risk Appetite Statement*[(1)].

A clear definition of Risk Appetite Statement allows stakeholders to have reasonable assurance on the company's full understanding of risks and its commitment to control them adequately.

When formulating a Risk Appetite Statement, the company has to underlight an originating source (called *Root Cause*), of the risk condition.

A *root cause* analysis is helpful for the whole risk management process: in fact, it can help the identification of related additional risks.

Specifically, the classifications and categorizations can help to better identify new risk scenarios or potential opportunities, but above all to develop a vision of enterprise-wide risk which is able to cover all potential events affecting the company, its processes and objectives.

The study of root causes it's also helpful for drawing up a *Risk List* (that will be is the first output from the risk identification step).

1.5.2 *Risk Assessment*

In order to implement a risk management system, the fundamental prerogative is to identify the plurality of random events that affect your organization. The risk assessment is the process aimed at the identification, measurement and evaluation of the events which, if they occurred, would involve economic, financial or company asset[29].

The assessment step is the ERM process' most technical phase and can be divided into *identification* phase and *evaluation* phase (*estimation* and *prioritization)*[17]. The objective is to define a list of acceptable and unacceptable risks, for which appropriate actions need to be taken.

- ***Risk Identification***

Risk identification aims to measure an organization's exposure to uncertainty. This requires a thorough understanding of the Organization of the market in which it operates, legal, social, political and cultural environment and the development of an adequate understanding of its strategic and operational objectives, critical success factors and the threats and opportunities related to them[21]. Risk identification should be faced with method to ensure that all significant activities within the organization are identified and that all the risks related to these activities have been determined. Finally, identified and classified all the *volatility* that are related to these activities. This phase consists in creating a sort of inventory of significant risks to which the company is exposed, categorizing it[17]. As I previously wrote, the risk identification starts with the study of a risk root cause and its first output is a Risk list.

An example of a risks list produced during the identification step is depicted in the following table: the risks list in tabular form is the main input for the next stage of the risk management process and will become the master risks list used during the subsequent management process steps (see *Figure 4*)[36].

Root cause	Condition	Consequence
Inadequate staffing	The service desk cannot handle the number of calls it is receiving.	The SLA will not be met and customers will have to wait longer for support.
Technology change	CRM software vendor plans to withdraw support for the current version of the product.	Existing CRM system will be unsupported.
New regulatory requirement	All e-mails and attachments need to be stored for eleven years.	Current backup and archiving software cannot accommodate this need.

Fig. 4 *– Example of an IT company risk list*[51].

The identification of corporate risks certainly has the benefit of allowing the company the implementation of a risk management system but also involves several critical aspects. In fact, this phase is costly in economic terms of time and resources. may also need to make use of external consultants when the dimensional structure requires it or when it is cheaper to outsource costs, human resources "releasable" and greater powers to be exploited, especially in terms of past experience: generally, this involves major consulting firms, very active in recent years in the field of risk management. Also in this case, it is necessary to involve subjects, knowledge of business and operational processes.

- **Risk Prioritization**: This step begins with the *risk assessment* and ends with their *prioritization*, in order to identify the unacceptable ones and then take

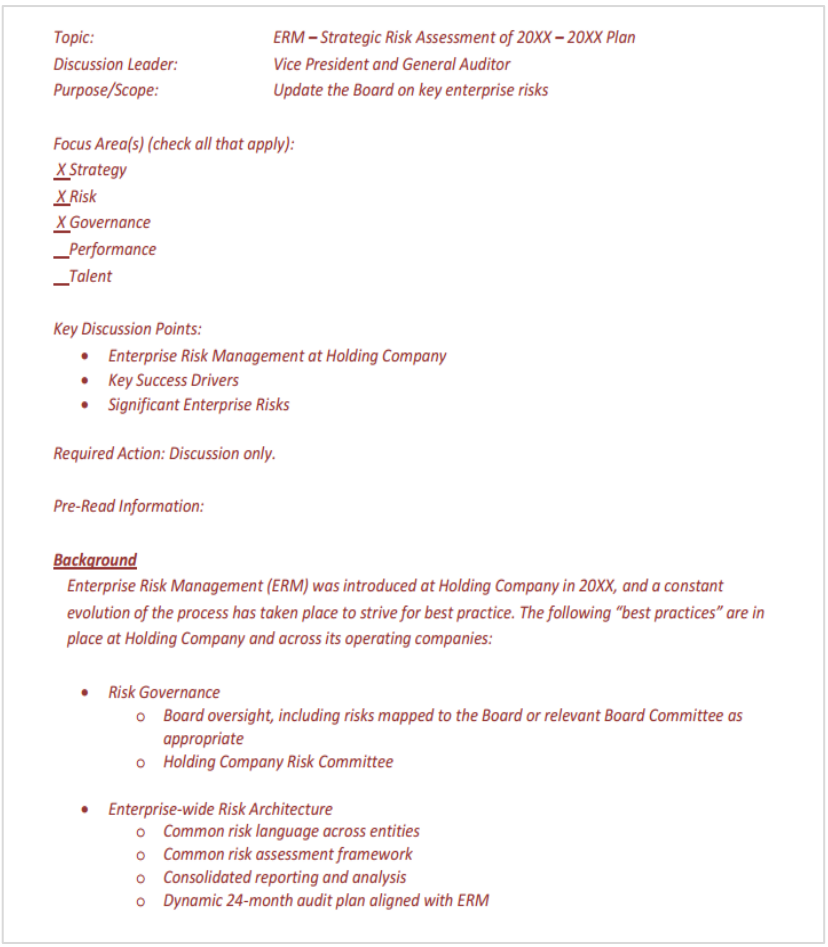
action[17]. This risk assessment step can be done by *qualitative*, *semi-quantitative* or *quantitative* techniques that will be explained through next paragraphs.

1.5.3 *Risk Reporting*

In this phase, *summary reports* should be prepared to highlight the main results of risk assessment and integration to enable those in charge to make appropriate decisions in the next phase of risk treatment[17]. The report is a structured document that presents all the risks that emerged in the identification phase, describing its main features, current management status, and ranking obtained in the previous phases and it could allow decision-makers to act based on a complete and detailed picture of the risks that they face in the organization+.

The description of the risk in the first summary report aims to show the risks identified in a structured way, for example through the use of a table or discursive documents (*pre-read documents*).

The use of a carefully designed structure is necessary to ensure a comprehensive process of identification, description and assessment of risks. The study of the consequences and the probability of each risk listed in the table should make it possible to prioritize key risks that require a more detailed analysis. The risks identified in the context of commercial activities and decision making can be classified as strategic, tactical, operational/design. It is important to put the risk management in the conceptual phase of a project and during the life of the project.



Topic: *ERM – Strategic Risk Assessment of 20XX – 20XX Plan*
Discussion Leader: *Vice President and General Auditor*
Purpose/Scope: *Update the Board on key enterprise risks*

Focus Area(s) (check all that apply):
X Strategy
X Risk
X Governance
__Performance
__Talent

Key Discussion Points:
- *Enterprise Risk Management at Holding Company*
- *Key Success Drivers*
- *Significant Enterprise Risks*

Required Action: Discussion only.

Pre-Read Information:

Background

Enterprise Risk Management (ERM) was introduced at Holding Company in 20XX, and a constant evolution of the process has taken place to strive for best practice. The following "best practices" are in place at Holding Company and across its operating companies:

- *Risk Governance*
  - *Board oversight, including risks mapped to the Board or relevant Board Committee as appropriate*
  - *Holding Company Risk Committee*
- *Enterprise-wide Risk Architecture*
  - *Common risk language across entities*
  - *Common risk assessment framework*
  - *Consolidated reporting and analysis*
  - *Dynamic 24-month audit plan aligned with ERM*

Fig. 5 *– Example of an IT company risk list*[12].

The figure (see *Figure 5*) provides an example of pre-read document that could be provided by one organization to their board during the reporting step.

These examples illustrate how a *pre-read document* can be used to help the board obtain a high level understanding of the current status of significant

enterprise risks faced by the company and then serve as a basis for a conversation between the board and the risk discussion leader [12].

The pre-read document isn't the only way to communicate risk assessment's outputs. In fact, risk issues can be discussed utilizing visual formats, such as heat maps, dashboards, scorecards, charts and graphs, with heat maps explicitly mentioned by the majority (see *Figure 6-7-8-9).*

Fig. 6 *– Example of a Strategic Risk Summary[12].*

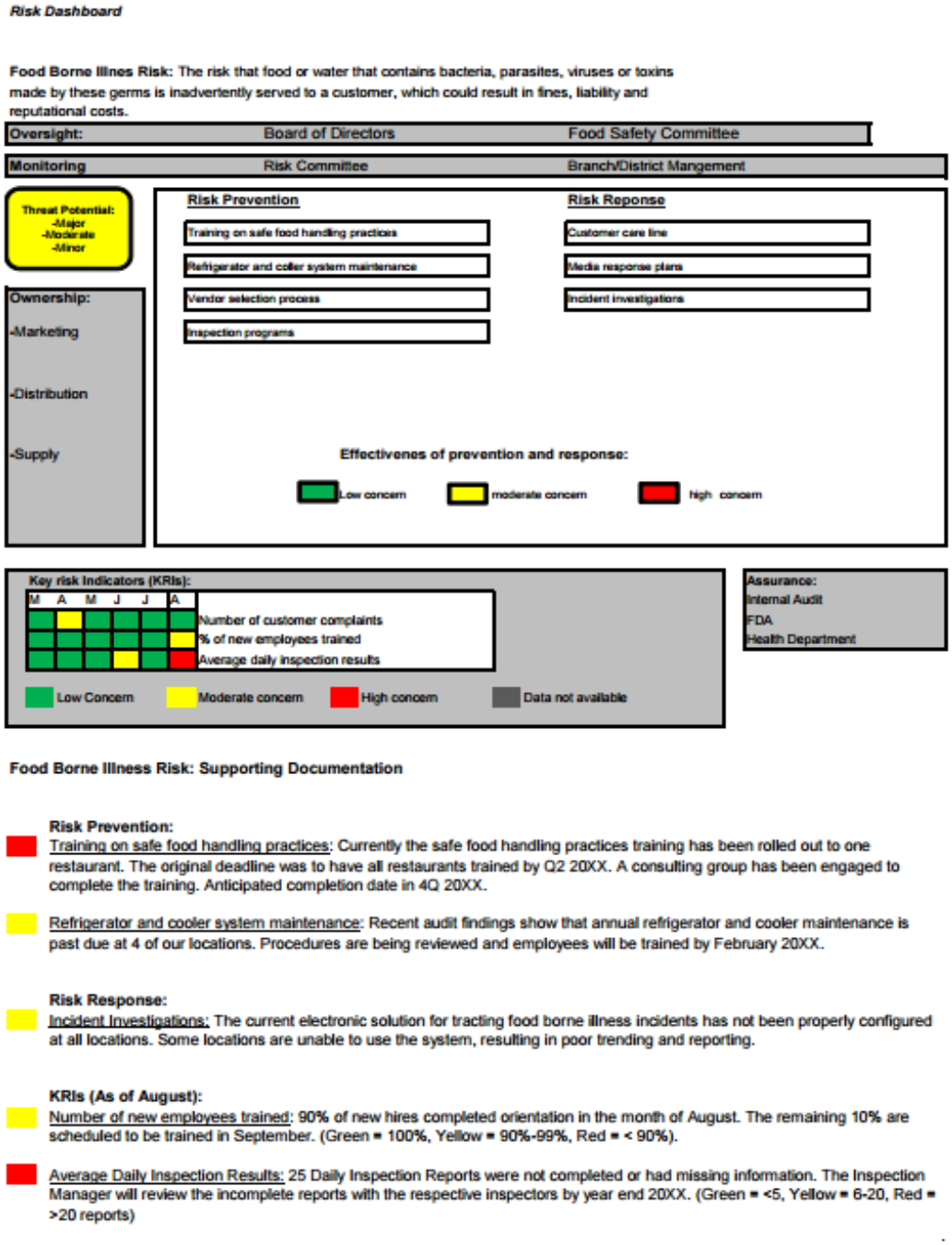


***Fig. 7** – Example of a Risk Dashboard (example 1)*[12].

Risk Category	Risk Description	Risk Owner	Last Assess Ment Date	Near Term Risk (Ability to Deliver Plan)	Strategic Impact to Business Model	Failure Risk Trend (1 – 3 years)	Overall Future Assess ment (1 – 3 years)
Strategic	Global Growth		August 20XX				
	Competition		August 20XX				
	Product		August 20XX				
	Brand		August 20XX				
Financial	Finance		August 20XX				
	Fin'l Svcs		August 20XX				
Operational	People		August 20XX				
	Parts & Accessories		August 20XX				
	Supply Chain		August 20XX				
	Manufacturing		August 20XX				
	Information Technology		August 20XX				
Compliance	Regulatory Compliance		August 20XX				
	Reputation		August 20XX				

Fig. 8 *– Example of a Risk Dashboard (example 2)*[12].

Risk Statement	Risk Owner		Risk Assessment		
Data Security: The potential risk of a data breach (internal or vendor) that results in a significant compromise of client data	**Executive**	**Primary**	**Financial Impact**	**Reputation**	**Likelihood**
	Smith	Jones	$100+ million	Severe	Possible
			Speed of Onset	**Trend**	**Objective**
			High	Increasing	Reduce

Emerging Risks & Factors Influencing the Risk Trend	Source
Weaker protections in the US have resulted in escalating rates of reported breaches involving payment card data. Etc.	External

Key Risk Response Activities	
Description of Activity	**Status**
Deployed new POS terminals eliminating client payment card data at point of sale Etc.	Complete

Key Risk Indicators				
Metric / Description	**Current Quarter**	**Prior(-1) Quarter**	**Prior(-2) Quarter**	**Prior(-3) Quarter**
# of open high-risk findings in risk register Etc.	#	#	#	#

Additional Comments / Related Risks
An optional cybersecurity framework was issued by NIST in February 20XX; we will be conducting a mapping/gap exercise over the course of the coming year Etc.

Fig. 9 *– Example of a Risk Scorecard*[12].

1.5.4 *Risk Treatment*

The treatment step consists of a set of activities aimed to reduce risks to bring them back within the enterprise's limits of tolerance and risk appetite[17].

The choice of the most appropriate technique depends on the type of risk involved and a careful cost-benefit analysis. Risk management methods can be classified in *ex-ante methods* and *ex-post methods*[17]:

- ***Ex-ante procedures*** concern management operations settled before the risk is manifested. These measures can in turn be divided into:
  - Do not take on
  - Prevention
  - Protection
  - Diversification
  - Coverage
  - Retention
  - Ex-ante monitoring (*risk exposure control*).

- ***Ex post procedures*** work after the risk has arisen and can be distinguished in:
  - Ex-post monitoring (*trend risk control*)
  - Containment measures and harm reduction (crisis management)
  - Financial and economical flows financing plans

To assist the management in implementing responses to risk choices, policies defined by top management must have operational feedback[19]. It is necessary to establish control mechanisms that take place throughout the organization, at all hierarchical levels and functional organizational structure. These activities include a number of different operations, such as permissions, consents, verifications, reconciliation, operative performance control, protection of company assets and segregation of duties. It is difficult to list what are the most common control

activities knowing that the checks reflect the environment and the industry in which it operates as well as the size and complexity of its organization, in addition to any undertaking is managed by different people that activate controls according to personal assessments.

1.5.5 *Other assessments and reportings*

At the end of the risk treatment step, it's necessary to do a second analysis of risks that will continue to affect the company [17]. These risks are called *residual risks* and require detailed mapping and accurate monitoring activity.

At the end of this step, a new report is prepared: a summary of the entire ERM process, which contains useful information to different business levels and external stakeholders to support business decisions and to evaluate processes' efficiency [17].

The reporting system instead can be classified into *internal* and *external*.

Internal Reporting

Different levels in an organization require different information on the risk management process.

The *Board of Directors* shall:

- know the most significant risks faced by the Organization
- know the possible effects on shareholder value due to deviations from the range waiting for performance
- ensure an adequate level of awareness throughout the Organization
- know how the organization intends to address a crisis

- be aware of the importance of stakeholder confidence towards the Organization
- know how to manage communications with the investment community where needed
- be sure that the risk management process functions effectively
- spread a clear risk management policy specifying the guidelines and responsibilities for risk management[21]

The *business units* must:

- be aware of risks which fall into their area of responsibility, the possible impacts these may have on other areas and the consequences other areas may have on them
- have performance indicators which allow them to monitor the key business and financial activities, progress towards objectives and identify developments which require intervention (e.g. forecasts and budgets)
- have systems which communicate variances in budgets and forecasts at appropriate frequency to allow action to be taken
- report systematically and promptly to senior management any perceived new risks or failures of existing control measures[21]

The *individuals* must**:**

- understand their responsibilities in the individual risks
- understand how to let a constant improvement of the results of risk management
- understand that risk management and risk awareness are a fundamental part of the culture of an organization
- systematically and promptly report to senior management any suspected new risk or malfunction in the existing control measures [21].

External Reporting

A company must regularly inform its stakeholders, including its risk management policies and the effectiveness in achieving objectives.

Stakeholders pay increasing attention to ensure that organizations demonstrate effective management of their non-financial assets areas such as community relations, human rights, recruitment procedures, health and safety and the environment[21].

1.5.5 *Risk Monitoring*

The monitoring step is at the end of the ERM process. "Monitoring" means checking the quality of the risk management system implemented in the company and assessing the achievement of the objectives identified during the planning step[17].

ERM systems must be continually modified, allowing them to flexibly adapt to market variables and changes in the internal structure: when the company changes its goals to be pursued, the strategy must be changed accordingly. Once the *residual risks* are identified, the company must implement the entire risk management process.

The two main methods identified differ in how often checks are made:

- **Continuous evaluation**: Continuous assessment is carried out consistently throughout the ERM process to find simultaneous deviations of results from the identified targets and it musts involve all business operators, and they need to know their tasks and colleagues so that they can evaluate both their own activity and that of the area they refer to[17].
- **Separate assessment**: this phase, it is not constant, but it is carried out at fixed intervals, whose frequency vary according to the degree of analysis desired by the company. These controls are used in situations where continuity would be

too burdensome or when the monitored area is sufficiently stable. The monitoring intervals are determined based on the risks frequency, and in fact the most likely risks will be subjected to more frequent controls, such as weekly controls, and low probability risks will have more extended time controls, such as monthly or quarterly.

These two monitoring methods must be used together, so as to continuously supervise the most vulnerable areas to risks, and change the control frequency when risks likelihood variates.

In addition, the control can then be structured on several levels and, in particular, is expressed in the following activities[19]:

- *Risk exposure control*: this activity can be considered a real risk management procedure (*management control*);
- Repetition of all or part of the Risk Management process if necessary: the process looks dynamic and must be repeated periodically and in any case, any time you change the ambient conditions, such as when editing a risk or the introduction of new management methods[19];
- Determination of the effectiveness of the Risk Management process and possible revisions of the same. A Risk Management process occurs when everything works so "ordinary": when you experience scenarios that were not foreseen or when in the presence of negative manifestations of risk reduction and harm reduction measures are operating correctly. If it is clear that some anomalies may be subject to malfunctions of the Risk Management process, the absence of anomalies does not allow to easily understand if the process is adequate or if it was just a favorable circumstance[19].

Finally, in addition to the checks outlined above, Risk Management, like any other business, should be subjected to the process of internal auditing and it must

be ensured that people called to define and achieve goals, policies, processes and procedures of Risk Management are acting correctly.

1.6 *Risk Mapping Fundamentals*

The measurement of identified risks can be done through three types of techniques:

- ***Quantitative***: these techniques are used to determine the distribution of the probability associated with the potential impacts of a risk event. The choice between the available quantitative techniques needs a preventive analysis by which the company will identify costs to sustain to realize it and the benefits of better knowledge of the examined phenomena(17).
- ***Semiquantitative***: these techniques assign numbers to the categories identified through the qualitative analysis. These numbers, however, do not represent a real quantification of the likelihood and impact of the risk, they rather serve to sort the different types of risks that have been identified(17);
- ***Qualitative***: these techniques employ descriptive sequences to represent the likelihood and impact of each identified risk. These techniques have a general nature and, in most cases, are used as a starting point for a more detailed study;

Qualitative and semiquantitative techniques are simpler and less expensive to use than quantitative ones.

The decision to use a technique rather than another depends largely on the quality and quantity of information available at the time of choice.

If the information available on risky events isn't exhaustive, it is reasonable to use qualitative or semiquantitative techniques considering the greater uncertainty that would make the costliest quantitative technique.

Regarding the type of risk to be estimated, the adoption of quantitative techniques is mainly used to measure financial risks, since uncertainty depends on such variables that can be easily investigated in the financial markets(17).

On the other hand, for the evaluation of operational and strategic risks, the use of qualitative or semiquantitative techniques is generally preferred because of the

greater uncertainty linked to the continuous changes in the environment that make the historical information available difficult to use[17].

The risk assessment consists in the estimation of two fundamental parameters defining the risk: the *probability* of manifestation of an uncertain event and the *impact* on the organization's ability to meet the set goals.

In estimating probability and impact, four different measurement scales can be used:

1. *nominal scale*: events are grouped into categories that describe the type without being sorted, graded or assessed (economic, financial, environmental, technological events);
2. *ordinal scale*: it establishes a scale or a certain order of importance, such as high, medium or low, in order to classify and categorize events in order of significance and according to their likelihood and their impact
3. *intersperse scale*: the events are sorted according to a precise numerical scale with equal distances between one class and another. However, to establish precisely the relationship allows not (the proportion of the impact) between events.
4. *proportional scale* relative to the scale intervals, allows you to determine precisely the relationship between events.

In addition, management must consider both "*inherent risk*" and "*residual risk*" when carrying out this step.

The *inherent risk* is the risk that a company assumes if the management has not made any intervention to modify the probability and impact. This risk is not affected by any company' strategic decision.
The *residual risk* is the one remaining after management has started its risk response.

Therefore, we can say that the risk is assessed firstly as an inherent risk and, after implementation of the risk response, as a residual risk.

1.6.1 *Quantitative Approach*

The objective of quantitative techniques is to determine the distribution of the random variable representing the risks under investigation.

There are typically two performances: the distribution of possible outcomes and the distribution of possible losses. The distribution of possible outcomes indicates the impact of risk on variable business goal (business assets, economic value or profit) assuming the neutrality of the other business risks[19].

For the quantitative estimate, there are many scientific models that can be employed.

We can, however, identify some fundamental steps that are common to all forms:

- construction of the model;
- determining the characteristics of random variables and random not;
- determination of distribution of results and indicators;
- determination and verification of the model[22];

The importance and complexity of each of the steps mentioned is variable depending on the specific problem to be solved.

In the case of corporate risks the model formulation is facilitated by monetary nature of the variables involved. Determination and estimation of characteristics of random variables and parameters, using appropriate statistical methods, can take

place primarily through hypotheses and theories supporting the model time series or on subjective assessments by experts.

The distribution of the random variable goal, instead, is generally determined by a simulation: it is a particular mode of decision-making based on guessing system building and on the conduct of experiments.

In the resolution, the distribution of the random variable is identified directly from a model, by virtue of the properties of random variables that constitute it. This method can only be used for extremely simplified models, when the random variables have a normal distribution.

When a resolution is not possible, simulated or numerical methods may be used. Among these, the Monte Carlo simulation technique is the most widespread: this method consists in extracting of random variables, values that correspond to the deployment expectation of risk factors in order to obtain alternative scenarios[19]. Once defined the relationships underlying the model, the simulation experiments can also occur through conducting certain analyses, as the sensitivity analyses and scenario. The first type of analysis measures the impact generated by the review of some risk factors on the system of values, to be able to determine the degree of sensitivity of the performance associated with the occurrence of certain risk factors.

Within the generic group of quantitative techniques, it is necessary to distinguish between *non-probabilistic, probabilistic techniques* and *benchmarking*.

Probabilistic techniques suggest a distribution of events behaviors. These methodologies are classified in:

- ***Value at Risk*:** identifies the variability of an expected value that is expected not to exceed a certain confidence level over a period of time;

- ***Cash Flow Risk***: similar to the previous one, identifies changes in the organization's cash flow (or an operating unit's one). It's a useful tool for businesses whose results are affected by the variability of cash flows;

- ***Earnings at Risk*:** predicting the variability of earnings included in the budget;

- ***Loss distribution***: statistical technique based on a hypothetical loss distribution, which is used in order to calculate, given some confidence level, maximum possible losses resulting from risk management analysis;

- ***Back testing***: tool frequently used by lenders. It allows the comparison between risk measurements and final data of a company[19];

Non-probabilistic techniques quantify the impact of a potential event on a distribution hypothesis without determining the probabilities of occurrence (that must be calculated separately).

In this case, we distinguish between:

- ***Sensitivity Analysis:*** studying the impact of changes in value within the company. It is often used as a complement to the probabilistic technique;

- ***Scenario Analysis:*** evaluating the effect of a panel of events on an objective;

- ***Stress Testing:*** assessment of the impact of events that give rise to serious effects [19].

Finally, ***benchmarking techniques*** are used to evaluate a specific risk in terms of likelihood and impact and consequently improve risk response for both sides. These can be Internal, competitive or sectoral, and Best in class. In the first case, there is a data comparison between different sectors; in the second case, the comparison is done between companies in direct competition or with similar characteristics, while the "best in class" compares measurements and similar data belonging to industries or companies with different characteristics.

The last step for all modes is always the determination and verification of the model: it implies the formulation of an opinion on the ability of the model to represent adequately the phenomenon, in case of positive assessment, obtained results can be used to carry out the subsequent phases of the Risk Management process.

1.6.2 *Semiquantitative Maps*

The semi-quantitative techniques assign classes identified through qualitative assessments of numbers at each level of probability and impact identified, allowing the company to assess risks using a score, called ***risk score*** (or *exposure*) [17].

The exposure of each risk rating is calculated by multiplying the weight associated with each level of probability of occurrence (*probability score*) with the weight associated to the corresponding expected impact[17]:

*RISK EXPOSURE = PROBABILITY SCORE * IMPACT SCORE*

The weights assigned to each class shall not constitute a quantification of probability, impact and risk, but rather allow the company to sort and compare risks.

Let's give an example of *risk score*:

Probability	**Score**
Almost Certain	100
Probable	50
Moderate	25
Improbable	5
Rare	1
Impact	**Score**
Catastrophic	1000
High	200
Moderate	50
Low	10
Insignificant	1
Risk Rating	**Combination**
Extreme	C ≥ 5000
High	C ≥ 500
Moderate	C ≥ 50
Low	C ≤ 50

Fig. 10 *– Example of a Risk Score*[24].

In this scenario (See *Figure 10*), the maximum risk rating is 100.000, and risks characterized by a risk rating higher than 5.000 must be controlled and managed through urgent strategies[16]. Then, other risks will be managed in accordance with the hierarchy.

The key aspect of this technique is the choice of weights per each class of probability and impact identified: it can assign a linear score that is proportional to the actual probability of occurrence and expected impact, or scores more than proportional or even scores that grow with decreasing rate[17].

After carrying out this measurement relatively to each identified risk, all estimated risks are inserted into the *probability-impact* matrix, that allows the company to have a joint vision of the same and an overall representation of the process/organizational unit's exposure to risk.

This risk map allows the company to sort risks per exposure level (high / medium / low): highest attention will be given to those risks that have a high level of exposure.

The use of qualitative or semi-quantitative estimation techniques seems to be justified only to make a screening of pure risks, to identify those risks that need to be analyzed through quantitative analysis and risks that may be overlooked or handled without resort to a more complex analysis.

1.6.3 *Qualitative Techniques: The probability-impact matrix approach*

The most commonly used methodologies are based on the direct subjective identification of the likelihood of occurrence and the impact of the risky event because companies in most cases do not have a wide range of historical business risk data which allow to estimate the parameters of the risky event by using statistical techniques

The most widespread qualitative technique is the "*probability-impact matrix*". In this case the evaluation is carried out by considering together the two parameters defining risk, probability of manifestation and expected impact, which are estimated by subjective evaluations(17).

The use of this technique requires first the definition of a qualitative scale representing the likelihood of manifestation of the uncertain event and a qualitative scale representing the expected impacts, or the economic consequences of the event. Each attribute used to define the two qualitative scales should then be associated with a brief description to facilitate and give uniformity to the

evaluation process. This allows the creation of specific categories of probability and impact based on which the identified risks will be categorized.

Relating to the likelihood and impact of the risky event, management can put each of them into the probability-impact matrix thus obtaining a mapping of the risks in the organization.

The probability-impact technique requires the definition of:

- A qualitative scale representing the probability of the adverse verification;
- A qualitative scale representing impacts/ economic consequences of the event;
- A qualitative scale assigning each combination of probability and impact a rating, called risk rating - as a matter of facts, probability-impact combinations are represented in a matrix form called PI matrix;
- A qualitative scale of the risk rating evaluation criteria, that is an indication of the attitude against a risk that has a certain risk rating[17].

The following picture provides an example of the highlighted steps (see *Figure 11*).

		Impact				
		Insignificant	*Low*	*Moderate*	*High*	*Catastrofic*
Probability	*Sure*	High	High	Extreme	Extreme	Extreme
	Probable	Moderate	High	High	Extreme	Extreme
	Moderate	Low	Moderate	High	Extreme	Extreme
	Improbable	Low	Low	Moderate	High	Extreme
	Rare	Low	Low	Moderate	High	High

Legend
Impact
Probability
Risk Rating

Qualitative description

Probability	*Sure*	High likely to happen event, which probabiliy it up to 50%
	Probable	Quite likely to happen event, which probability is from 20% to 50%
	Moderate	Low likely to happen event, which probability is from 5% to 20%
	Improbable	Unlikely to happen event, which probability is from 1% to 5%
	Rare	Very unlikely to happen event, which probability is not upper than 1%

Impact	*Insignificant*	Negligible economic effects on the company
	Low	Low economic effects on the company
	Moderate	Moderate economic effects on the company
	High	High economic effects on the company
	Catastrofic	Disastrous effects on the company

Risk Rating	*Extreme*	Underlights the need of immediate risk management actions
	High	Underlights an accurate risk evaluation from CRO
	Moderate	Underlights a risk evaluation from line manager
	Low	Underlights day by day procedures

Fig. 11 *– Probability-Impact Matrix* [2].

[2]Figure created by the author.

The choice of probability, impact, risk rating and evaluation criteria is entrusted to the common sense of the risk manager: there are five probability classes (from rare to almost certain), five impact classes (from insignificant to catastrophic) and four risk rating classes (from low to extreme). Each rating class corresponds to a risk assessment (See *Figure 12*).

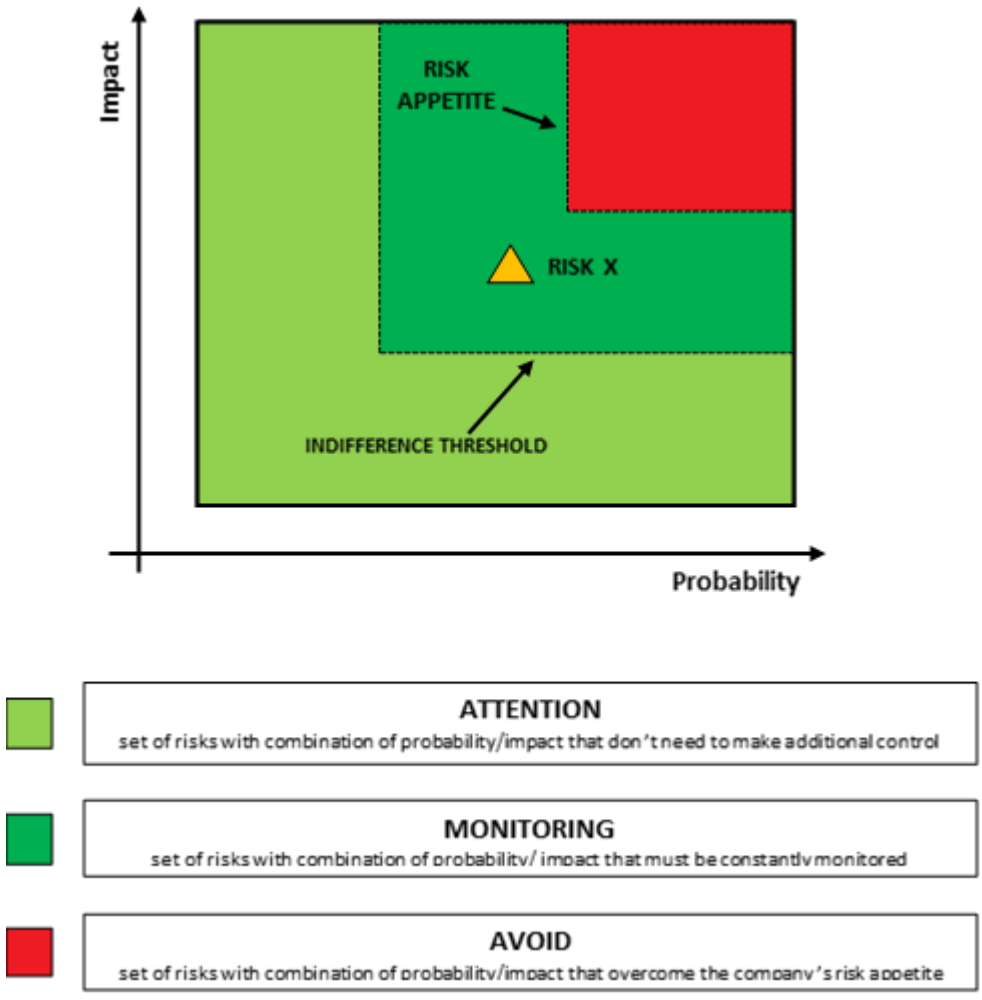


Fig. 12 *– Actions to implement after Probability-Impact Matrix Analysis* [3].

[3]Figure created by the author.

- Risks associated with *high / extreme rating*, are characterized by a high damage and a significant probability of occurrence. These risks can jeopardize the enterprise's survival;

- Behind a *moderate rating* there is the occurrence of an event that can potentially cause damage to the organization's operations. These could be risks characterized by minor damage entities but with a significant likelihood of occurrence or, on the other hand, risks characterized by critical damage entities but with a low likelihood of occurrence;

- Risks with *low ratings* are those that can be left on when allocating the control resources. In any case, these risks must be periodically checked to ensure they maintain the same criticality level and they are characterized by a negligible impact and an unlikely chance of occurrence.

The probability-impact technique is extremely simple and inexpensive to implement. It is however considered that its scope is necessarily limited to pure risks' activity screening, namely the identification of those sheer risks that require a detailed study to be implemented through a proper quantitative technique. The actual applicability is also limited to the risks in which there are only two possible scenarios: the scenario in which nothing happens and the scenario in which a loss occurs that determines a well-defined impact[17].

1.6.4 *RMA: from qualitative to semi-quantitative methodology*

Probability Impact matrix, in the public imagination, are mostly seen as a qualitative method. As a matter of facts, the two indicators "probability" and "impact" are measured from a qualitative point of view, more specifically, from the company people perspective. This kind of risk matrix is based on judgements and qualitative scales representing likelihood and impact, as I previously wrote.

However, the *probability-impact matrix* (and its extensions) can be intended as a semi-quantitative tool.

Of course, the risk matrix features are the same, and these are as follows:

- Be simple to use and understand;
- Not require extensive knowledge of the use of quantitative risk analysis
- Have clear orientation to applicability;
- Have consistent likelihood ranges that cover the full spectrum of potential scenarios;
- Have detailed descriptions of the consequences that relate to each consequences range;
- Have clearly defined tolerable and intolerable risk level;
- Show how scenarios that are at an intolerable risk level can be mitigated to a tolerance level on the matrix;
- Provide a clear guidance on what action is necessary to mitigate the scenarios with intolerable risk levels. (18)

It should further be noted that the basic rules to produce a risk matrix are not so similar: in fact, the probability is calculated with numbers and expressed quantitatively, and not just with a qualitative managerial judgement.

We can say that the semi-quantitative risk matrix is used for ***quantitative measurement of likelihood*** and ***qualitative judgement of consequences***.

The probability classification scheme shown below is extracted from *ICAO Doc 9859 - Safety Management Manual*; it specifies the probability as qualitative categories, but also includes numerical values for the probabilities associated with each category[53].

	Probability of Occurrence Definitions				
	Extremely improbable	Extremely remote	Remote	Reasonably probable	Frequent
Qualitative definition	Should virtually never occur in the whole fleet life.	Unlikely to occur when considering several systems of the same type, but nevertheless has to be considered as being possible.	Unlikely to occur during the total operational life of each system but may occur several times when considering several systems of the same type.	May occur once during total operational life of one system.	May occur once or several times during operational life.
Quantitative definition	$< 10^{-9}$ per flight hour	10^{-7} to 10^{-9} per flight hour	10^{-5} to 10^{-7} per flight hour	10^{-3} to 10^{-5} per flight hour	1 to 10^{-3} per flight hour

Fig. 13 *– Probability of Occurrence Definition in International Civil Aviation Organization SMM[53].*

The figures below show firstly a risk list, the list that should be done before the production and analysis of the semi-quantitave matrix. Subsequently, there is an example of semi-quantitative probability-impact matrix:

Levels of severity and probability.

Severity	Scale	Description	Probability	Description
Critical	4–5	Cannot achieve key term or major program milestone	0.00–0.10	Remote
Serious	3–4	Major slip in key milestone or critical path impacted	0.10–0.40	Unlikely
Moderate	2–3	Minor slip in key milestones and not able to meet need dates	0.40–0.60	Likely
Minor	1–2	Additional resources required but able to meet need dates	0.60–0.90	Highly likely
Negligible	0–1	Minimal or no impact	0.90–1.00	Near certainty

Critical	M	H	H	H	H
Serious	M	M	M	H	H
Moderate	L	M	M	M	H
Minor	L	L	M	M	H
Negligible	L	L	L	M	M
Origin	0.00~0.10	0.10~0.40	0.40~0.60	0.60~0.90	0.90~1.00

Fig. 14 *– Example of semi-quantitative probability-impact matrix*[5]

The output of the risk matrix analysis is the risk index, that is generated by levels of severity and likelihood.

This matrix shows three different zones:

- The green one shows low risk- low impact area
- The yellow one shows medium risk – medium impact area
- The red one shows high risk- high impact area

The risk matrix (both qualitative and semi-quantitative type) has a significant defect that when applied to a specific case, sometimes different risks may share the same risk level: these risks are called ***risk ties***, resulting from two major limitations of RMA, namely the non-meticulous classification of risk index (only

three qualitative levels) and the prescriptive assessment mechanism based on the subjective calculation process of logic implication; the existence of risk ties makes the assessment result vague because they do not contribute at all to the differentiating of input risks in terms of criticality[5].

To overcome these defects and increment RM applicability, the literature has proposed several alternative risk matrixes. Below, an example of these will be provided: *Figure 15* shows the so called ***fuzzy risk map***, compared to the traditional risk matrix approach.

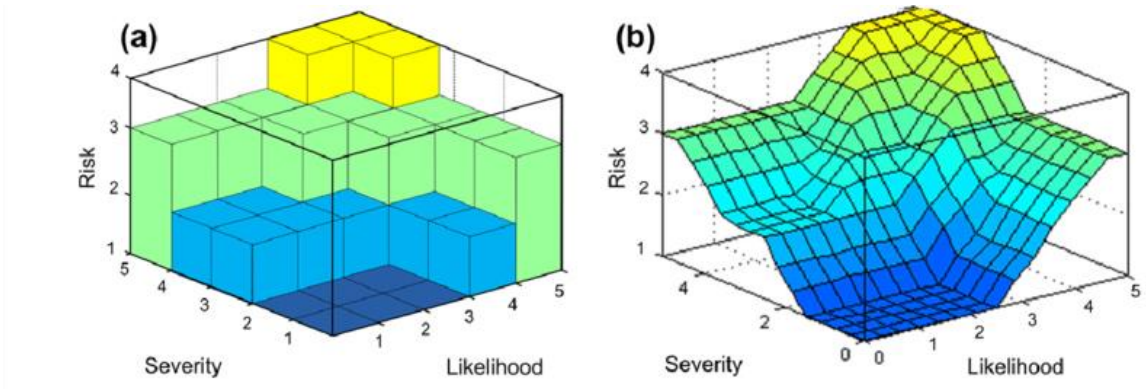


Fig. 15 *– Comparison between (a) traditional risk graph and (b) fuzzy risk graph*[54]

The *fuzzy risk matrix* is a semi-quantitative method whose aim is to get over traditional risk matrix problems.

In order to build a fuzzy risk matrix (FRM), the following steps are needed:

1. Define fuzzy sets for FRM, including linguistic terms of variables and description range;
2. Select proper membership functions for variables;
3. Design a fuzzy inference system to map fuzzy input sets to fuzzy output sets;
4. Select a *defuzzification* technique to convert combined fuzzy conclusion into a crisp form;
5. Develop the graphical edition of FRM.[5]

CHAPTER II

EYETRACKING AND MANAGERIAL RISK PERCEPTION EXPERIMENT

People's actions have always been guided by something that eschews simple rationality. These emotions and feelings affect our everyday life in all its aspects. In this chapter, the theme of managerial risk perception will be analyzed, and will be explored how behavioral habits, emotions, feelings, culture and other elements which influence the human psyche, can influence people's actions within a business environment.

The analysis will focus on the study of two disciplines related to Behavioral Accounting and Neuroeconomics (with specific focus on Neuroaccounting): these fields study the reactions of our brain within certain business issues. Then, will be explored the behavioral psychology issue applied to management decisions, studying brain and eyes behavior during the decision-making process.

More specifically, we will apply theories that are shown by these disciplines through practical experiments based on the use of innovative technology, known as *Eye Tracking*, used to measure fixations, saccades and other eye movements of users during experiment.

Referring to first chapter, the second one will look through this methodology studying people visual reactions during assumption of risk.

The goal of this experiment will be providing a complete mapping of the physiological reactions of individuals during the decision to adopt a certain level of risk in four scenarios.

2.1 *Behavioral Accounting Research and Neuroeconomics*

"*A philosopher of science once suggested that the last thing a fish would discover would be water. And so, it would seem to be for accountants, for it is only within approximately the last decade that accountants have become aware of the behavioral structure within they function*.[26]"

In the accounting process, people play a very important role. They can be considered as the actors of the economic processes: the accounting process can be altered by the effects of collective and individual behaviors. The results of this kind of research can be useful for many stakeholders as it reports the premises of the final decision making process.

The main issues of Behavioral Accounting Research are "*the influence of management control systems on the behavior of organizational participants, the influence of accounting information on internal and external users, and the behavior of accountants themselves*[8]" as Ashton summarized in 2010.

As accounting is oriented on actions and behaviors, its purpose is to influence the latters directly through the information of the message, and indirectly through the behaviors of accountants. Behavioral accounting can be considered as the application of the behavioral sciences to accounting. The purpose of the study is to analyze the decision-making process through the behavioral sciences.

The expression Behavioral Accounting appeared for the first time in 1967 in the Journal of Accounting Research. It's been coined at the University of Chicago in the 40s. The goal of this science is to analyze and predict the human behavior in any economic context. This helps to reduce problems occurring in the accounting process.

It is important for accountants to be aware of the complexity of the different reactions of people to accounting process that can depend on both psychological and cultural values. That is why accounting needs to rely on behavioral science (the study of individual and collective behavior).

Many other fields can help in the research: psychology, psychiatry, political science, sociology, anthropology and so on. The most important one is of course psychology.

Psychology helps accounting in studying the influence of other people on individuals' behavior, the cognitive process, the way people organize informations etc.

In sociology, the perspective is focused on the way information is analyzed by different kind of cultures. That is why BAR is considered a very interdisciplinary field of study: the proliferation of research method has meant that BAR is more than laboratory experiments, surveys, and the occasional field study; a variety of archival databases have been used to investigate essentially behavioral issues[10].

An important research, known as human information processing research, helps to understand decision making in accounting. As Caplan said in 1966, "*an*

understanding of behavioral theory is relevant to the development of management accounting theory and practice"[8].

Psychology and neurosciences are very important to this research. The union of economics, psychology and neurobiology led to a new study called Neuroeconomics.

Neuroeconomics analyzes the process that influences decision making from a neurobiological point of view. This science field, and Behavioral Accounting Research as well, have an important starting point, that breaks through the boundaries of classic theories: theorists should stop thinking about people's brain as a "black box".

Our purpose must be trying to open that box (that, in fact, is the main goal of the experiments that I conducted), studying the whole mechanisms that affect it, and nowadays there is a huge number of statistic, mathematic and electronic tools that can help us to do this (e.g., fMRI, EEG, …).

The birth of Neuroeconomics doesn't have the purpose to get ahead of classical theories, but to complete them, trying to understand the neurochemical basis of our choices - as a matter of facts, people don't ever behave as classical theories predict.

To provide an explanation of what I mean, I'm giving you an example: the scientific journal *Nature* has demonstrated that in financial investments, giving oxytocin to individuals, they invested higher sums of money because they feel more confident. It's evident that investors (and, generally economic actors) can calculate indexes or do any kind of rational prediction but brain has ever the last word.

2.2 *Innovations of Neuroaccounting*

"*Neuroeconomics defines decision-making as the product of brain processes relative to anticipation, representation, selection and valuation of choices and opportunities. Neuroeconomics also carefully analyzes the whole process of decision into mechanistic components*[37]."

The research in Behavioral accounting has met many difficulties over the years as it hasn't been much considered by scholars. According to Basu, this research was "predominantly conducted in an ivory tower with little connection to problems faced by practitioners". The system itself still lacks experimentation and innovation.

Behavioral accounting wants to explore the way accounting influences human decisions. For this purpose, accounting needs to collaborate with neuroscience.

Neuroaccounting research is the one that presents most of innovations in the field of accounting. It can be considered as the evolution of behavioral research as its goal is no longer to observe the human decision, but to analyze how humans react to stimuli.

Neuroeconomics is the union of neural and social research. Its approach is mainly through the experiments in laboratory and the examination of behavior, which help to create a theoretical map of how humans make decisions. Anyway, neuroeconomics is still moving its first steps as a science.

"*Given the difficulty in performing a neuroaccounting study relative to the early laboratory experiments in BAR, the volume of neuroaccounting research is likely to be small.*[41]"

As modern society is becoming more and more complex, modern accounting has to adapt to its rhythm. So, the innovations in accounting can lead to improvement of the human condition.

Analyzing the parallelism between brain and accounting, Dickhaut (2009) argues that the genesis of social rules takes place in the brain, the main accounting institution. As the brain, has been evolving biologically in accounting process, Dickhaut argues that also accounting rules have been changing in parallel.

According to neuroscience, the existence of accounting is due to the evolved structure of brain. To understand the brain structure means to understand future actions. The complexity of the task brings people to use a system of recordkeeping.

Waymire (2014) argues whether "*Neuroscience can help us to identify the ultimate causation for accounting*". Causation, which can be proximate or ultimate, helps to analyze the pattern of past events and to predict future events.

2.3 *The brain and its decision-making process*

An important research of Neuroaccounting is to study the way accounting influences the brain process of decision making.

In the 60's, more than one hundred experiments were published on how accounting influences the brain and its decisions, that means how accounting and managerial information and numbers affect managers' decisions in investment. Other researches focus on the way managers exchange emotional and economic factors in their decisions.

Recent studies use fMRI to investigate more directly on how brain behavior reflects economic behavior and how the brain responds to profit and losses. According to this research, earnings lead the brain to increase the neuronal activity especially in some specific areas (ventral striatum).

Neuroscientists have observed the brain during the process of earnings and returns. In particular, researchers have measured the brain behavior using BOLD technique (blood oxygen level dependent). The results are relevant in the correlation between earnings and the activity in the ventral striatum. The reaction of the brain is more relevant when facing a loss. This suggests there is a link between the brain's activity and positive/negative aspects of accounting, in general, of company performances.

Through these recent researches neuroscience can find out the relation that occurs between accounting process, the brain function and economic methods. Anyway, this research is still quite new and is having difficulties moving on. This is due to the fact that this kind of research is complicate and requires expensive instruments.

Behavioral researches still haven't the proper competences to use neuroscience methodologies and can only succeed through an interdisciplinary research.

An important neuroscientific methodology -the eye tracking methodology, that I'll explain through next pages- focuses on the eye fixation and saccades when an individual is processing an economic decision.

2.4 *How Business Studies Human Brain*

The main unit of the nervous system is the neuron. In the brain, hundreds of billions of these cells work to transmit nervous pulses. Anatomically, the part of the brain that works for accounting processes is in the neocortex, located under the skull. The neocortex is composed of four parts: frontal, occipital, temporal and parietal. Each of these parts has its own function.

Neuroaccounting research tries to analyze the way neurons interact between them in order to create a specific behavior in accounting.

fMRI (*functional magnetic resonance imaging*) research takes several pictures of participants' brains while performing accounting process to observe the movement of neurons. In other methods, electrodes are placed to detect neurons.

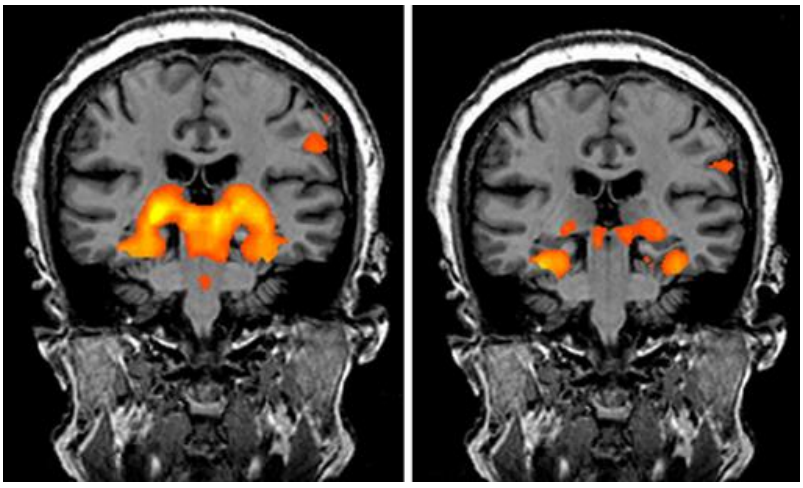


Fig. 16 – *fMRI scan example during hippocampus activity*[39]

The Eye tracking methods, instead, observe eye movements and fixations which are the expression of the brain's work.

Fig. 17 *– Eye tracking experiment example* [46]

Accounting is linked to the morality of humans. It needs the presence of ethics and the ability to create trust and wealth, that is the key of economic relations. Immoral behaviors are so highly penalized by this system. This is the reason why accounting can be considered as a social rule that encourages moral behavior.

Behavioral science is composed of a cognitive process (*the evaluation of information)* and affect process (*the reaction to stimuli*).

Behavioral science could also research how accounting influences behavior and vice versa, how behavior influences accounting. There are people who are more inclined to commit fraud, for example. Accountants may have brains which are genetically more proper for their job.

Another interesting research is in framing effects. If someone has to choose between a gamble and a secured thing, he will surely choose the assured thing if the result is framed as a profit, but he will choose the gamble if the result is framed as a loss.

Neuroeconomics is studying the way emotions can influence the decision making and whether individuals can control their decision-making process.

2.5 *Eye fixation and eye movement*

"Records of eye movements show that the observer's attention is usually held only by certain elements of the picture. Eye movement reflects the human thought processes; so, the observer's thought may be followed to some extent from records of eye movement (the thought accompanying the examination of the particular object). It is easy to determine from these records which elements attract the observer's eye (and, consequently, his thought), in what order, and how often.(35)"

The observation of the way humans visualize reality has always been related to the study of the human brain. Neurobiology and cognitive science has studied the transmissions of signals from the retina to the brain. The question remains of how this process generates actions and decisions. Neuroeconomics aims to study the relation between the visual input process and the decision-making process.

It is sure that the eye movement is linked to attentions and behavior. The *gaze*, the changing of direction, could mean the rise or the decrease of attention.

Individuals may observe what interests their attention and this could lead to a choice. Eye movement researchers aim to understand the relation between eye shifts and cognitive process.

Psychology and business studies (firstly, marketing researches, then other business fields) have underlined the importance of visual attention related to the decision-making process. The attention of eye movements affects people's choice. The object observed is also influenced by individual's preference in the selection of its features.

Visual attention can be divides into three sections:

- *Section one: the spatial attention*

The spatial attention can be overt (the eye movement is linked to the attention) or covert (the eye movement isn't linked to the attention).

- *Section two: the FBA*

FBA (*feature-based attention*) is guided by the aspects of the observed object (such as the shape, the color, etc.)

- *Section three: the OBA*

OBA (*object-based attention*) is guided by the structure of the object.

Anyway, the process of attention needs to pass a selection of inputs. Not everything we see can attract our attention. Attention helps us to focus on the things which are relevant to us and to avoid things which are not important.

Attention can be focused by gazing in a direction (*overt attention*) or by looking at the periphery of an object without directly staring at it (*covert attention*). Covert attention helps us to in monitoring the environment.

Visual attention can also be:

1. *Orienting*, which focuses on the center of the attention
2. *Detecting*, which focuses on the context.

So, attention doesn't always depend on the movement of the eyes. We can focus our attention even by looking somewhere else.

"The observer's attention is frequently drawn to elements which do not give important information but which, in his opinion, may do so. Often an observer will focus his attention on elements that are unusual in the particular circumstances, unfamiliar, incomprehensible, and so on.[35] *"*

Decision making process is very complex. The researches usually focus on the results of the decision-making process rather than on the process which brings to these results.

Just and Carpenter (1975) asked: "How the rapid mental operation of the central processor are reflected by the pattern and duration of eye fixations during a task involving visual input? How eye fixations parameters such as locus, duration and sequence reveals the fine structure of the processor's activity in performing a number of cognitive tasks?".

About 25% of the brain is involved in vision. The visual process starts with the perception of light signals by the eyes. The inputs move to the brain through specific neurons (photoreceptors) which translate the light signals in electrochemical signals. So, the movement of the eyes is strictly connected to the cognitive process.

Eyes can move in six directions: three movements in socket and three rotations. Six muscles allow eye movement:

1. The medial and the lateral recti, which allow the sideways movement,
2. The inferior and superior recti, which allow down/up movement,
3. The inferior and superior oblique, which allow eyes to twist.

Eye movements are generated by the oculomotor plant, that is the neural system.

Moving to directions according to the attention, eyes make movements (***saccades***). In between saccades, they remain still for about 200-300 Ms. Saccades are quick movements (500° per second) and can be voluntary or reflexive.

There are three other types of eye movements: pursuit, vengeance and vestibular movement. Anyway, saccades are more relevant in the process of attention.

There are also ***fixations***, that is when the eyes remain still over the object of interest. Anyway, eyes are never entirely still. Even during fixations, there are movements of tremors, micro saccades or drift.

The three types of movements that are relevant in the attention process are ***saccades***, ***fixations***, and ***pursuits***.

Fixations show the interest to an object of interest, whereas saccades show the need to change the direction of the attention. Gaze is involved directly in the decision formation.

The following Guyton and Hall quotation is to explain saccades:

"When a visual scene is moving continually before the eyes, such as when a person is riding in a car, the eyes fix on one highlight after another in the visual field, jumping from one to the next at a rate of two to three jumps per second. The jumps are called saccades, (...) the brain suppresses the visual image during saccades, so that the person is not conscious of the movement from point to point"[25]

On the other and, *pursuits* (or *smooth pursuit movements*) are movements that allows us fix our eyes on a specific object when this object of interest is in movement.

A complex mechanism is able to sense the movement of an object and develops a complementary course of movement for the person's eyes[7].

2.6 *Eye-tracking technology*

Researches have shown the importance of eye movements related to the decision-making process. The eye tracking technology has been very successful in the study of visual attention. It measures the direction of visual attention and the relation between the gaze and the pupil dilatation. It indicates what a person is looking at and so his overt attention, but also the time he looked at a certain point, the blinks, the pupil dilatation and saccades.

There are many eye-tracking methods. The most used ones are those that study the eye movements while people are using a computer – this is also the methodology used during the managerial risk perception experiment. They focus on the gaze direction, the eye position and the pupil dilatation.

They aim to understand what attract users' attention. Another methodology is the infrared corneal reflection methodology, related to the position of the pupil.

"*There are four broad categories of eye movement measurement methodologies involving the use or measurement of: Electro-OculoGraphy (EOG), scleral contact lens/search coil, Photo-OculoGraphy (POG) or Video-OculoGraphy (VOG), and video-based combined pupil and corneal reflection*[(20)]".

Fig. 18 – *Example of EOG experiment*[20]

Fig. 19 – *VOG based tracking*[4]

Eye-trackers can measure the direction of gaze in relation to the head or the movement of eyes in the open space.

Eye movements are the easiest way to get information from the environment and are so related to deep cognitive process. The innovations that neuroeconomics

is finding through the use of eye-tracking methods make researchers believe that this methodology may be applied to BAR. As I said, BAR needs new methodologies which can study the decision-making process and not only its results.

2.7 *Eye tracking applications*

As I previously wrote, *Eye tracking* is a very innovative method through which researchers study users eyes movements to know their behavior and attitudes.

The figure below shows an example of this kind of experiments (See *Figure 20*).

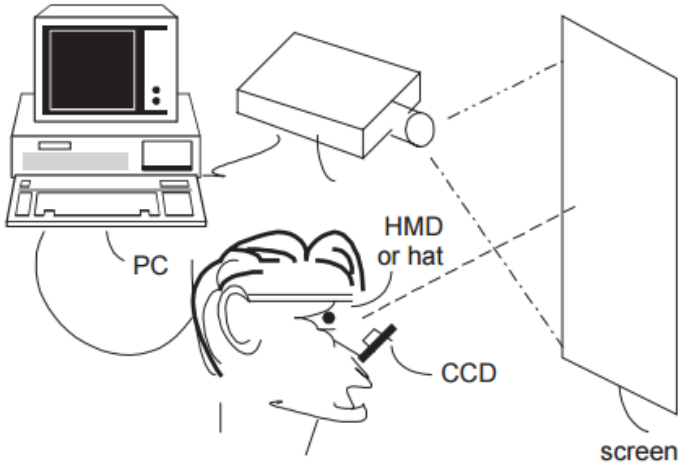


Fig. 20 – *Computer setup using eyetracking method*[3]

As a matter of facts, this kind of technology is used in a very wide range of fiels, e.g.:

- *Clinical research*

  Eye movement analysis is studied, e.g., for the identification of ocular disease, as well as mental and neural disorders such as autism spectrum disorder, ADHD, and Parkinson's disease[43]

- *Gaming*

  In this case, researches study players eyes to design a computer game (the most famous pc game designed is Assassin's Creed).

- *Infancy research*

  The book "*Eye tracking Technology Applications in Educational Research*" provides a lot of examples of experiments in this field, such as analyses of reading processes, children's attention, and so on.

- *Neuroscience and psychology*

  A specific area of this field (I mean business applications) will be examined in depth next pages through the managerial risk perception experiment;

- *Consumer research*

  In this case, eyetracking is a very useful tool to do market researches in order to study product positioning: by the way, during these experiments, consumers are invited to wear glasses that analyses where and what people look at, and with how much intensity.

  This field, called Neuromarketing, is a science that belongs to Neuroeconomics (as Neuroaccounting), and is also focused on measuring marketing and advertising impact on customers. The figure below shows an example of Neuromarketing experiment in which Tobii eyetracker was used (see *Figure 21*).

Fig. 21 – *Tobii glasses during a consumer research*[40]

All these field of research (Just the most widespread fields have been mentioned, but truthfully, the Tobii application area is wider) have a shared issue. In fact, eye tracking is used in these fields of research to understand the connection between what we see and how we react, based on the information we process[40].

At this stage, a question has left open: *what actually is Tobii and how it works?*

Tobii is a comprehensive platform for the recording and analysis of eye gaze data, facilitating the interpretation of human behavior, consumer responses, and psychology: combining an easy preparation for testing procedures and advanced tools for visualization and analysis, eye tracking data is easily processed for useful comparison, interpretation, and presentation.[32]

The Tobii eye tracker consists in a lightweight machinery composed by complex algorithms and sensors. The figure below (see *Figure 22*) shows Tobii sensors: camera and projectors. All these components are implemented on a computer to figure out what the user is seeing.

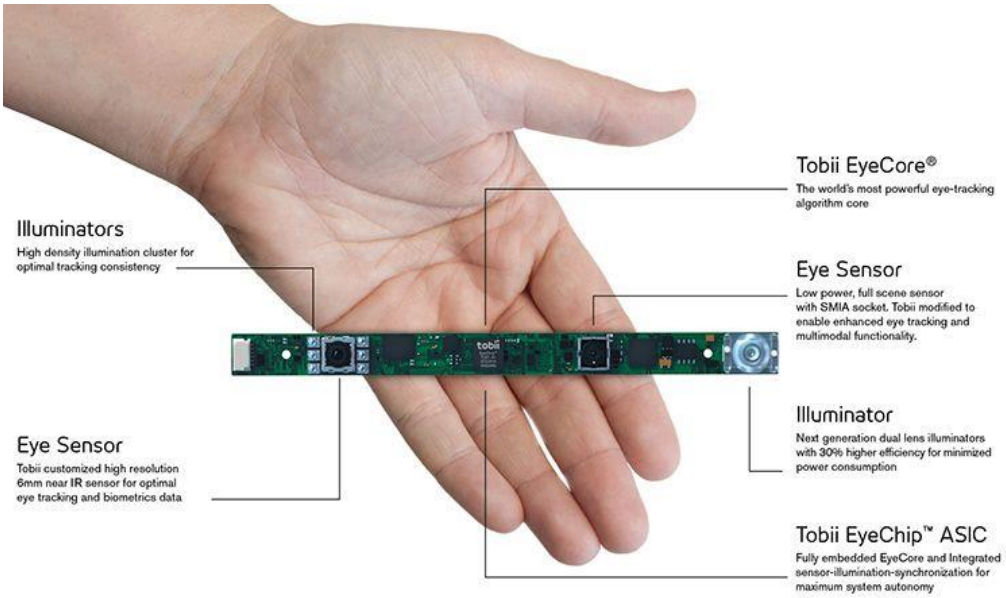


Fig. 22 – *Tobii bar components*[42]

In detail, Tobii is composed by:

- *Advanced micro projectors*

  Which are used to create a reflection pattern of NIR (Near-Infrared) light on the eyes.

- *The sensors*

  Captures high-frame-rate images of the user's eyes and reflection patterns.

- *The Image-processing algorithms*

  The intelligence of the system, which finds specific details in the user's eyes and reflection patterns, and interprets the image stream generated by the

sensors. They calculate the user's eyes and gaze point on a device screen.

- *User-oriented applications*

  An intelligent application layer is added to enable the various ways the technology can be used(45)

The figure below (see *Figure 23*) sums up the Tobii working principles.

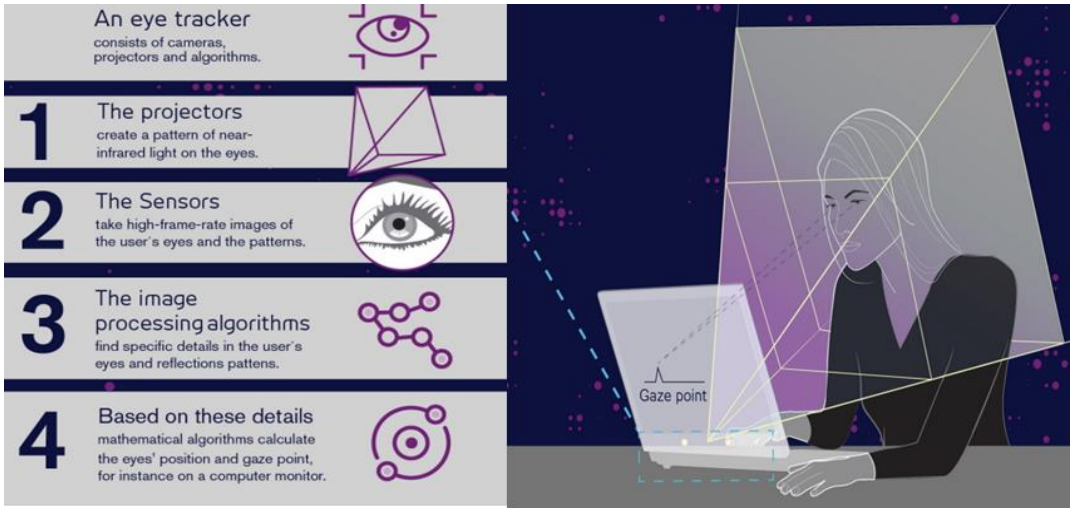


Fig. 23 – *Tobii bar components(45)*

2.8 *Tobii data collection*

As in photo cameras, the light reflected from a surface passes through a lens and arrives to our eyes, which analyze the inputs.

Our eyes don't perceive an object as a whole but through small features which attract our attention. Finally, the whole object is built through the information acquired previously.

Fig. 24 – *Scene Perception* [33]

Our eyes can only focus on small parts of the reality, and so need to make a process of selection, that is called attention. Furthermore, our view is also quite slow at recording information, compared to modern computer screens. The retina can record an image in 80 Ms. The way we record an image is also influenced by the light conditions and what is being observed.

As we previously wrote, eye-tracking is a technique that measures eye movements to detect visual attention. Modern techniques have become less intrusive in testing users. Eye-tracking devices study people's visual attention while performing tasks such as reading, driving, etc. We can only see the world through fixations, while during saccades our vision is impossible.

The eye-tracking techniques records users' eye movements and then presents them to user in order to see their reaction. While the device records the eye movements, the software analyzes them.

A non-intrusive innovative method is the PCCR (*pupil center corneal reflection*). It analyzes the way eyes react to a light source through a picture of the cornea and the pupil. A vector formed between the cornea and the pupil will calculate the direction of the gaze.

Tobii eye tracker improved the PCCR methodology by using infrared to create the reflection on the eyes while sensors record the way eyes react to the reflection. Through algorithms and 3D models, the gaze orientation is then estimated.

PCCR eye tracking can use two different options: the bright pupil eye tracking, where an illuminator brightens the pupil, and dark pupil eye tracking, where the illuminator is not nearby, which causes the pupil to be dark.

There are several causes which can influence the results of this test. During the bright pupil eye tracking, there might be other factors which can change the size of the pupil: the light of the environment, age, ethnicity and so on. It has been noticed that on Caucasians and Hispanics the bright pupil eye tracking works better than on Asians.

Tobii eye tracking device use bright and dark pupil techniques to evaluate the eye orientation. It is able to deal with any condition and ethnicity of the participants, that are initially tested to see which method works best for anyone.

Before the test starts each individual has to submit to the process of calibration. In this process the device analyses the eye characteristics of the users. The user is asked to look in different areas and the device records pictures of the eyes.

During the test Tobii registers eye movements points every 16.6 or 8.3 Ms. Each point is identified as x or y coordinates and sent to the software.

"Tobii Studio uses two types of fixation filters to group the raw data into fixations. These filters are composed of algorithms that calculate whether raw data points belong to the same fixation or not. The basic idea behind these algorithms is that if two gaze points are within a pre-defined minimum distance from each other then they should be allocated to the same fixation – in other words the user has not moved the eyes between the two sampling points.(33)

Fixations which are registered by the device are represented in graphics by dots (the larger the dot, the longer the fixation time), while saccades are represented by lines. Another representation can be made with a heat map, which uses different colors to indicate the concentration of fixations in a specific point and their duration.

The color red indicates a high quantity of fixations or a longest duration, while green indicates the lowest quantity of fixations or the shortest duration. Areas with no color indicate they were not relevant for users (see *Figure 25-26* below).

Fig. 25 – *Gaze Plot or Scanpath image*[33]

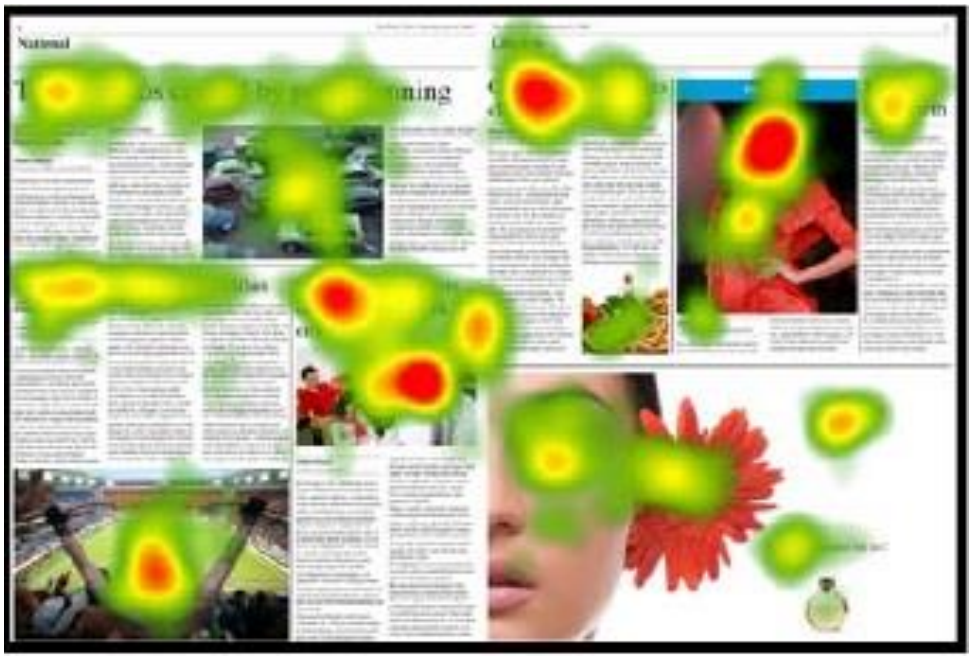


Fig. 26 – *Eye Tracking Heatmap*[33]

Tobii eye tracker can calculate the position of the eyes and the pupil size in order to study the emotional reactions. "Several definitions exist regarding what

should be defined as the size of the pupil. In the eye model used by Tobii Eye Trackers the pupil size is defined as the actual, external physical size of the pupil. However, in most scientific research the actual size of the pupil is less important than its variations in size over time[33]".

The phenomenon of blinking can influence the eye tracking, as it blocks the illumination to the pupil and so the resulting coordinates x,y.

Head movements, instead, don't really affect the eye tracking. "The Physiological 3D Eye Model of each participant's eye offers an accurate and more robust way to determine the position of the eye and point of gaze of the participant independent of head movement[33]".

Humans can't generally stare at one object for a long time. Even during fixation, the eye is not still, but moves involuntary and constantly. This can influence the eye tracking device. Anyway, eye trackers can record the position of the eyes in a very accurate way.

Another element of disturb in the eye tracking methods is represented by drifts. Drift makes the trackers less accurate and can be caused by changes in the eyes (wetness, dryness) or in the environment (light variations). Anyway, the problem can be solved by frequent calibration. Tobii tracker can handle quite well the problem of drift.

Fixations do not always indicate a cognitive process. There are many factors to analyze. "For example, during a search task one can easily fixate briefly on the search object and miss its presence, especially if the object has an unexpected shape or size (commonly called *change blindness*) [33]".

A high number of fixations can also result from the personal interests of the user or from the difficulty to understand that area.

2.9 *Beyond the Experiment*

The experiment's starting point is the willingness to analyze managerial risk perception.

Risk perception refers to people's judgments and evaluations of hazards they (or their facilities, or environments) are or might be exposed to: such perceptions steer decisions about the acceptability of risks and are a core influence on behaviors, people's risk appraisals are a complex result of hazard features and personal philosophies, and risk attitudes are people's intentions to evaluate a risk situation in a favorable or unfavorable way and to act accordingly.

Eye tracking is able to tell us whether screeners look at papers, how long they look at them, what parts of resumes they look at, and in what order they look at each part[28].

The managerial risk perception experiment main goal is investigating some processes regarding the evaluation of firm risks.

The output will be providing a complete mapping of physiological reactions of individuals during the decision to bare a certain level of risk in different situations.

2.9.1 *The methodology*

- *Users*

This scientific research employed a cluster of 12 MBA students. In fact, to complete the experiment, we needed the collaboration and availability of people who has a managerial smattering which enables them to understand business patterns: the assessment consisted in considering a series of dimensions like economic, financial, reputational, regulatory, etc. and people had to act like an operations manager.

Of course, questionnaires and other documents were completely anonymous to protect students' identity.

- *Procedure*

The experiment is articulated in two phases:

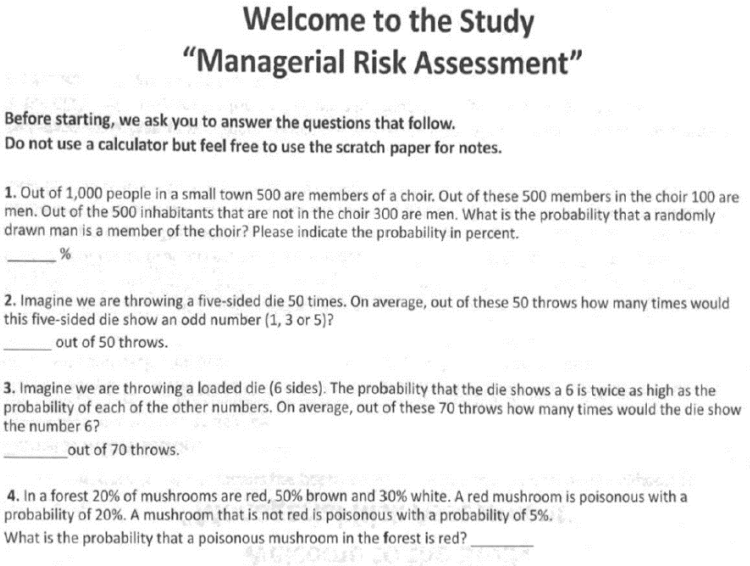
1. People are asked to complete a short paper questionnaire in which they should solve mathematical and statistic problems without using a calculator, in order to analyze their attitude to mathematical calculus.

2. People are asked to analyze some risk maps, matrices and the probability of some risk events and then to conduct a risk assessment based on the information provided. In this phase, we employed the eye-tracking device whom technology has been explained though the previous pages.

- ***Phase I***

The paper questionnaire consisted in solving four short problem.

The following picture (*Figure 27*) provides an example of these questionnaires.



Welcome to the Study
"Managerial Risk Assessment"

Before starting, we ask you to answer the questions that follow.
Do not use a calculator but feel free to use the scratch paper for notes.

1. Out of 1,000 people in a small town 500 are members of a choir. Out of these 500 members in the choir 100 are men. Out of the 500 inhabitants that are not in the choir 300 are men. What is the probability that a randomly drawn man is a member of the choir? Please indicate the probability in percent.
_____ %

2. Imagine we are throwing a five-sided die 50 times. On average, out of these 50 throws how many times would this five-sided die show an odd number (1, 3 or 5)?
_____ out of 50 throws.

3. Imagine we are throwing a loaded die (6 sides). The probability that the die shows a 6 is twice as high as the probability of each of the other numbers. On average, out of these 70 throws how many times would the die show the number 6?
_____out of 70 throws.

4. In a forest 20% of mushrooms are red, 50% brown and 30% white. A red mushroom is poisonous with a probability of 20%. A mushroom that is not red is poisonous with a probability of 5%.
What is the probability that a poisonous mushroom in the forest is red? _____

Fig. 27 – *Managerial Risk Assessment Test*

We've asked to fill this kind of questionnaire to analyze students' attitude to mathematics and scientific calculation, the so-called *numeracy skill*.

Being numerate means having the confidence and skill to use numbers and mathematical approaches in all aspects of life - at work, in practical everyday activities at home and beyond, as consumers, in managing our finances, as parents helping our children learn, as patients making sense of health information, as citizens understanding the world about us(55).

It means being able to:

- Interpret data, charts and diagrams
- Process information
- Solve problems
- Check answers
- Understand and explain solutions
- Make decisions based on logical thinking and reasoning(55).

Those who answer correctly to these four questions (or, at least 2 of 4), are expected to be more "matrix addicted", compared to people who have less numeracy skill.

So, we expected that people who have higher numeracy skill feel more confident to matrices instead of maps. This skill is also estimated by time spent in filling the questionnaire.

- ***Phase II***

During the second phase, people are asked to see a slideshow, in which they should look at four different scenarios:

1. ***Safey and Environment*** scenario: people should evaluate what investment in Safety and Environment is a priority in the light of the exposure of the production line to the risk identified;

2. ***Supply Chain*** scenario: people should evaluate what is the organizational mode of the supply chain that present the greatest risk esposure in relation to the targets identified during the strategic planning process;

3. ***Supplying of special parts for assembly*** scenario: what situation requires priority attention on the part of management because the company is most exposed to risk;

4. ***Production*** scenario: which investment in modernizing the production line will reduce production time least, leading to the greatest risk exposure.

Each scenario is characterized by the presence of a different graphic representation (matrix or map).

People's task is to answer the question that will appear at the end of every experiment. People are also required to stand still and look at the screen during the whole second part of the experiment, to enable the eye tracking device to record people's eye behavior.

The image below (*Figure 28*) illustrates a student employed in the experiment:

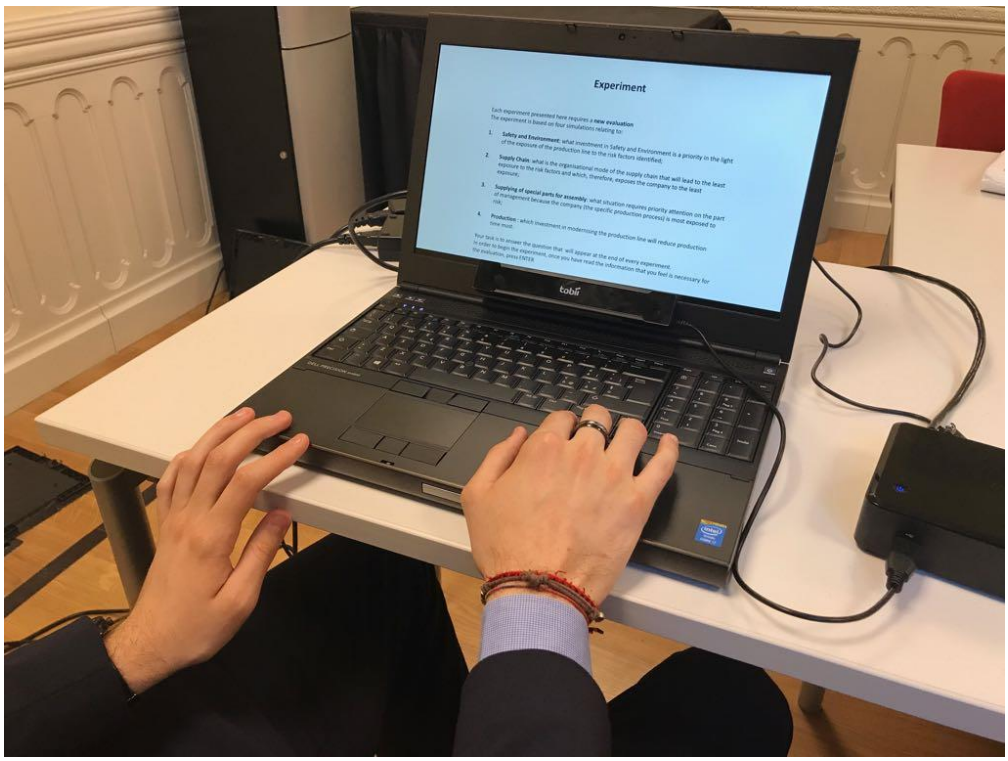


Fig. 28 – *MBA Student employed in MRP Experiment*

2.9.2 *Data Analysis*

Once concluded the data gathering step, though the next pages will be shown and explained first and second phases outputs.

Phase I

The goal of this phase is to show and analyze the paper questionnaire answers, in order to individuate who has the highest numeracy skill. Feeling more confident with mathematics, and, in general, with numbers, numerate people is expected to pay attention on matrices to better understand patterns.

The *phase I* output will serve to highlight if people who have outstanding numeracy skills will actually focus their attention on matrices instead of maps.

Using the cognitive theory, we can write that a user's reliance on graphical displays of various informations depends on task complexity and his or her level of task-specific knowledge and experience.

On the basis of that theory, Vessey states that "*matching representation to tasks, leads to the use of similar problem-solving processes, and hence the formulation of a consistent mental representation. There will be no need to transform the mental representation to extract information from the problem representation and to solve the problem. Hence, problem solving with cognitive fit leads to effective and efficient problem-solving performance*[4]."

Since "nonprofessional" users tend to have lower levels of task-specific knowledge and experience, they will rely on these graphical displays to reduce cognitive effort when making risk evaluations and judgments, regardless of task type(6).

On the other hand, "professional" users will not rely on graphical displays when engaged in the -relatively simple- task of evaluating current year earnings performance(6). They will rely on these graphical displays to reduce cognitive effort only when performing the more complex tasks of making judgments.

[4] See *Cognitive fi theory* in https://is.theorizeit.org/wiki/Cognitive_fit_theory

The picture below (*Figure 29*) shows the percentage of correct answers per each person:

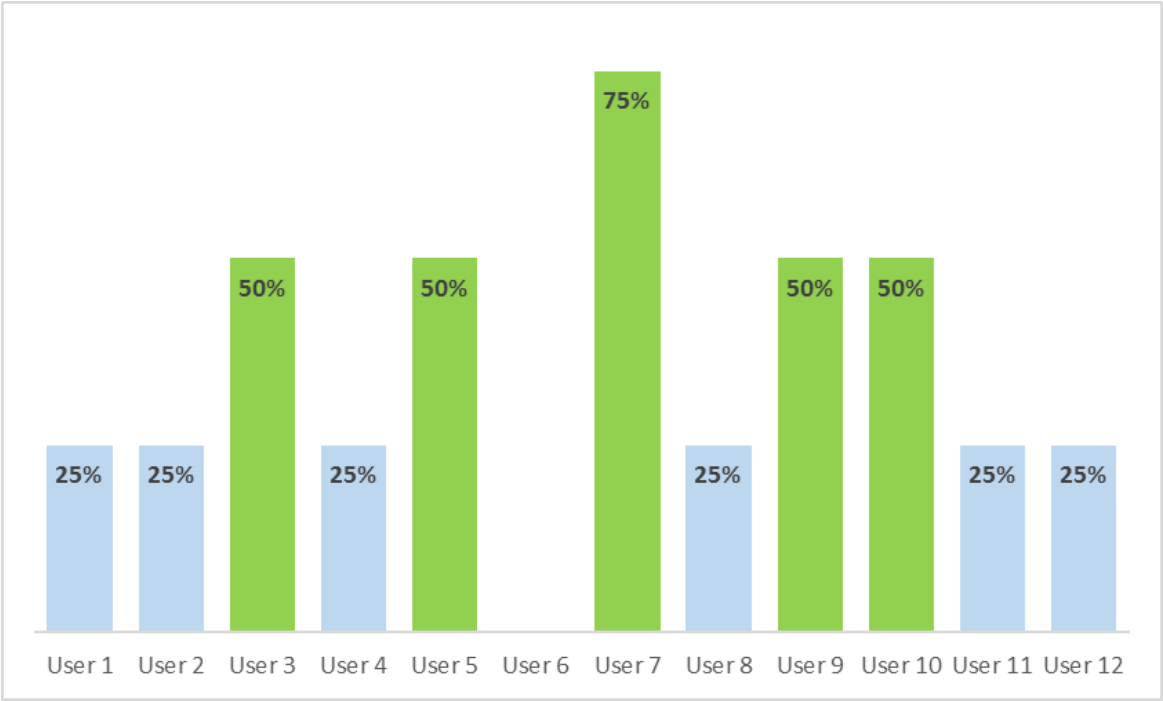


Fig. 29 – *Percentage of correct answers for each user*

In this experiments, two thresholds have been chosen to estimate numeracy skill levels:

- Number of correct answers _ 50% at least;
- Time of questionnaire filling _ ten minutes at most.

The analysis of people's answers to the paper questionnaire highlighted that the 40% of people can be defined numerate: in fact, they did at least 50% of correct answers with an average filling time of 8 minutes.

Through the *Phase II* data analysis, will be also shown the eye-tracking results, to know where their attention is focused on, calculating the amount of time spent watching maps and matrices.

Phase II

As specified before, during the *phase II* students are employed in eye tracking experiments.

Watching the slideshow, people should look at four different scenarios.

These scenarios describes four different business situation: per each scenario, users are asked to look at 3 different options, choosing the riskier one (risk evaluation process).

It must be noted that scenarios are represented by maps and matrices, as follows in the figures:

- Scenario 1 and 3 are represented by matrices (see *Figure 30*)

Scenario 1

	Likelihood	Impact
Risk Factor "#12"	0,60	3,25
Risk Factor "#03"	0,30	3,00
Risk Factor "#07"	0,45	1,75
Risk Factor "#15"	0,15	3,00

	Likelihood	Impact
Risk Factor "#05"	0,75	3,85
Risk Factor "#01"	0,65	3,75
Risk Factor "#07"	0,25	2,25
Risk Factor "#15"	0,45	4,65

	Likelihood	Impact
Risk Factor "#10"	0,80	4,25
Risk Factor "#03"	0,40	3,75
Risk Factor "#01"	0,25	2,25
Risk Factor "#15"	0,15	4,65

Scenario 3

	Likelihood	Impact
Risk Factor "#12"	0,6	4,15
Risk Factor "#03"	0,35	4,50
Risk Factor "#07"	0,35	2,25
Risk Factor "#15"	0,30	4,85

	Likelihood	Impact
Risk Factor "#05"	0,70	2,85
Risk Factor "#01"	0,65	3,45
Risk Factor "#07"	0,05	3,65
Risk Factor "#15"	0,85	2,15

	Likelihood	Impact
Risk Factor "#10"	0,90	4,25
Risk Factor "#03"	0,30	3,75
Risk Factor "#01"	0,25	2,50
Risk Factor "#15"	0,15	4,65

Fig. 30 – *Scenario 1 & 3 Matrices*

This representation provides a more detailed view of the data than the graphic representation.

- Scenario 2 and 4 are represented by maps (see *Figure 31*)

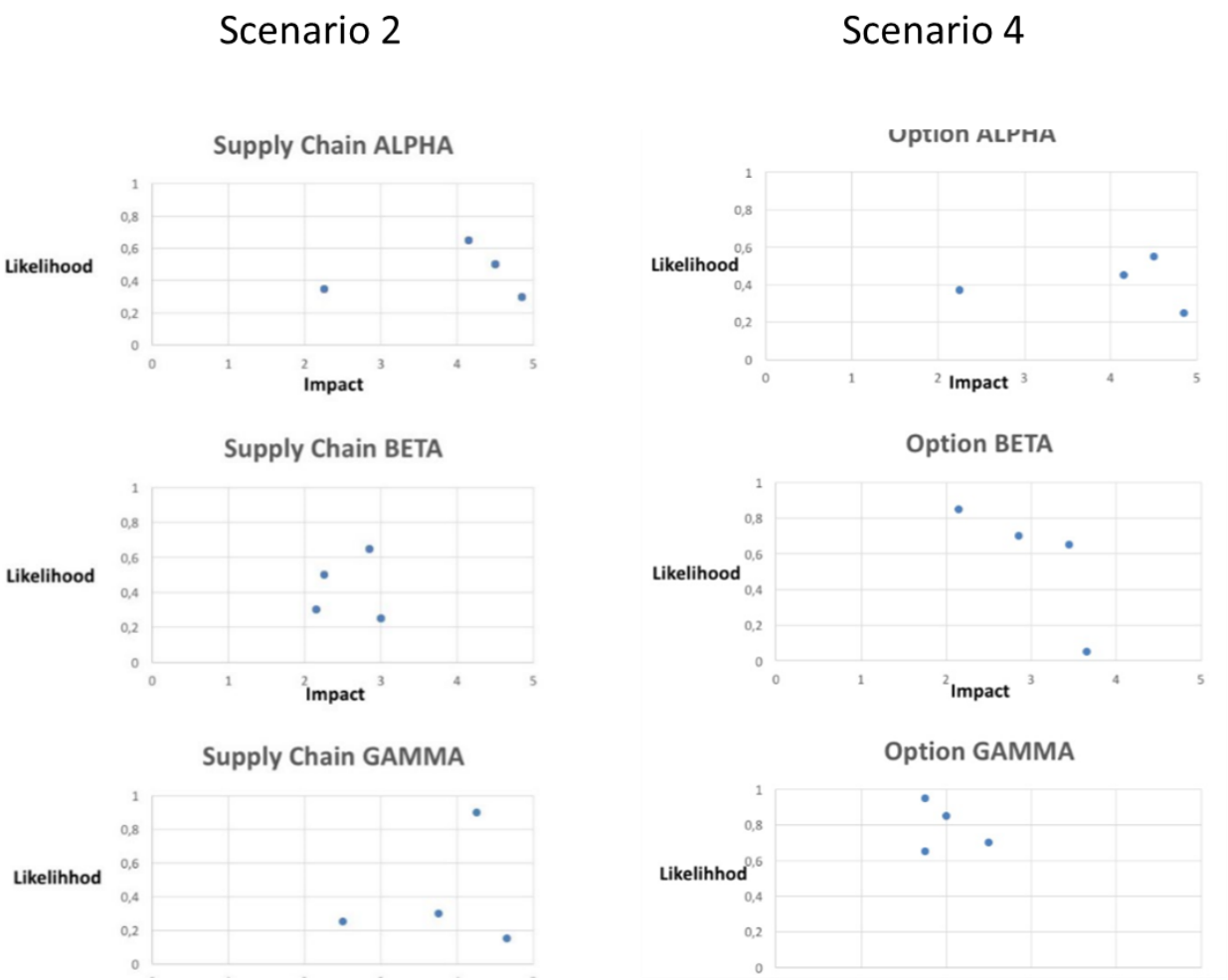
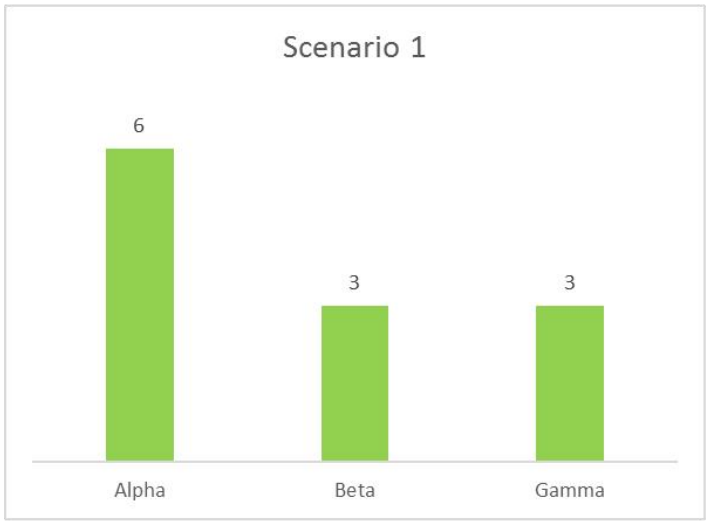


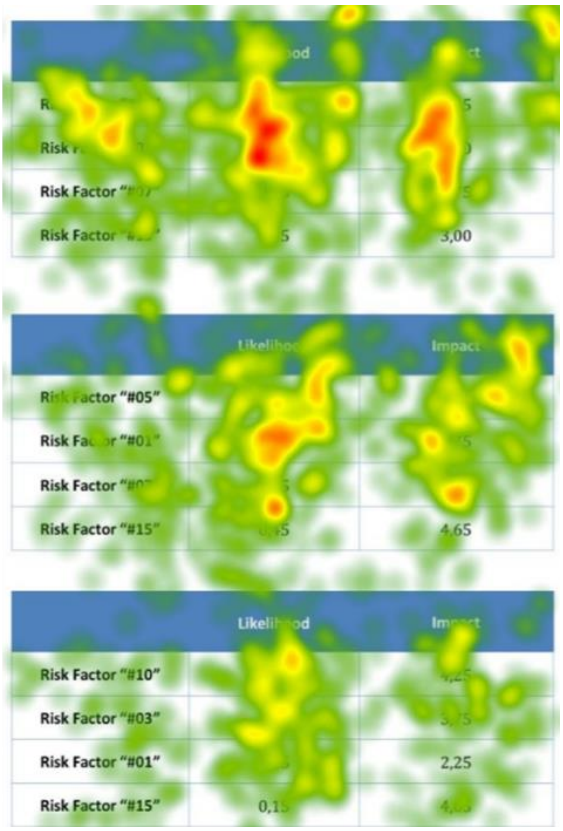
Fig. 31 – *Scenario 2 & 4 Maps*

Showing data in the form of charts instead of matrices should provide users with a more intuitive and quicker analysis.

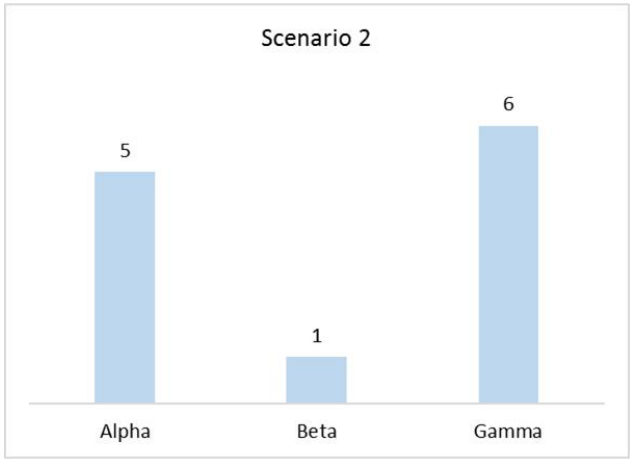
The figures below show answers per each scenario and the corresponding heat map, in which it is analyzed the correspondence between the answers provided and the amount of time spent analyzing a particular graph or matrix.

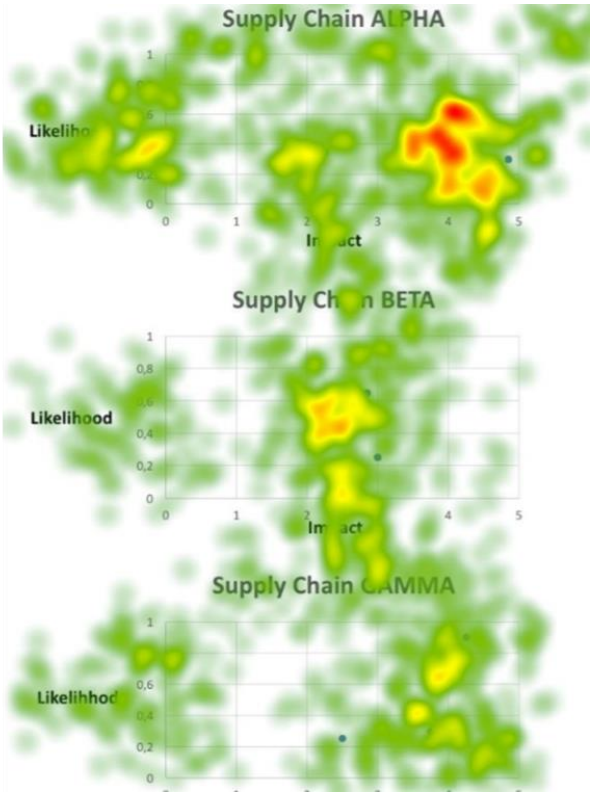
1. *Figure 32 - Safey and Environment*



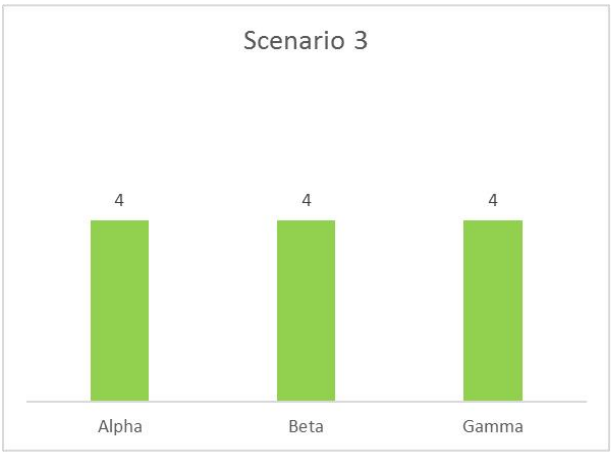


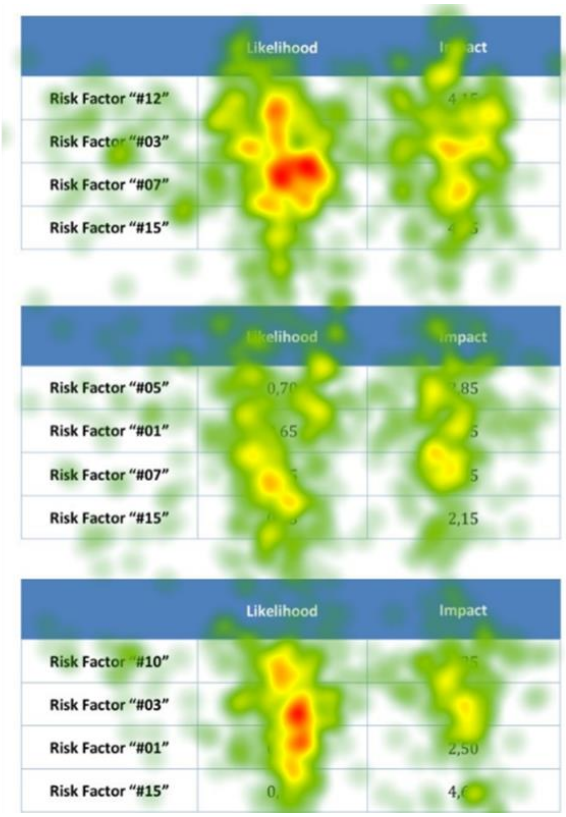
2. *Figure 33 - Supply Chain*



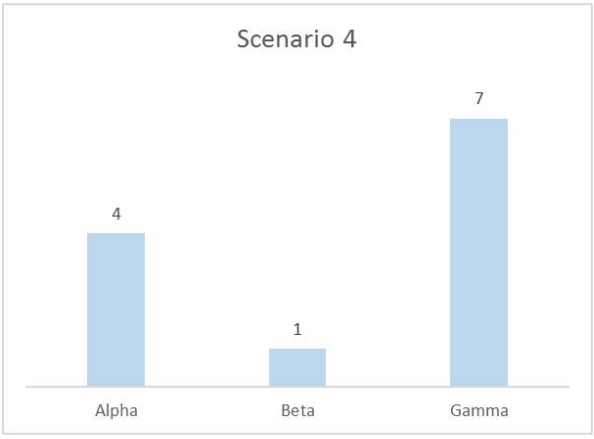


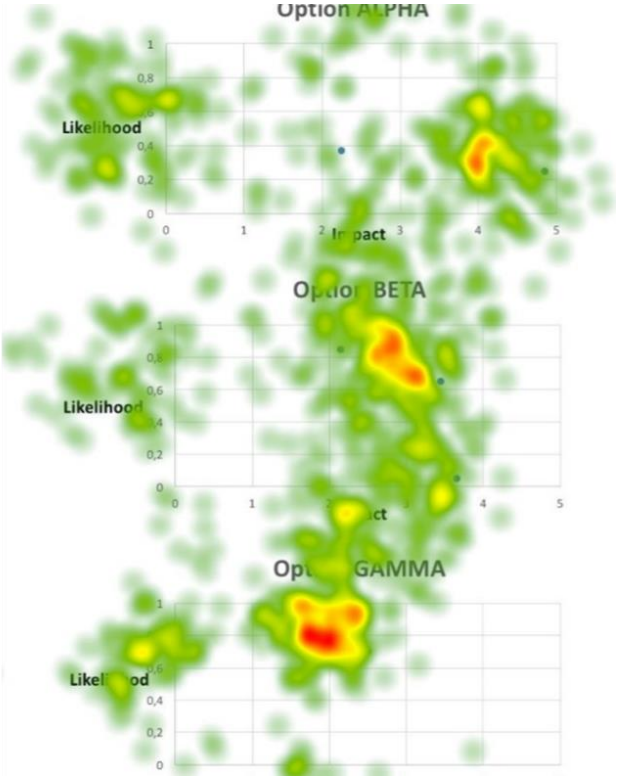
3. *Figure 34 - Supplying of special parts for assembly*





4. *Figure 35 - Production*





Looking through these data, we can conclude that people have chosen the options watched for longer: in the whole four scenarios, users have focused their attention on figures corresponding to options they felt riskier.

The results from the analysis of the previous four graphs also provide another interesting point of view. The answers provided by the students appear to be more homogeneous in the analysis of data represented in graphic form rather than in matrix form. This assumption may be related to the fact that the graphic representation provides to the viewer the ability to quickly and easily perceive the answers he thinks are right, unlike the matrices require a more careful and accurate analysis.

The graph below (*Figure 36*) shows trends of time spent watching the scenarios (in seconds). As can be seen, the total amount of time spent watching matrices (corresponding to scenarios 1 and 3) is 62, 52 seconds, and the total amount of time spent watching maps (corresponding to scenarios 2 and 4) is 43,29, almost 20 second less.

Fig. 36 – *Avg. Time Spent in scenarios visualization*

The pie chart (*Figure* 37) represents in percentages the effective time spent by students within the entire experiment for the matrices and maps analysis.

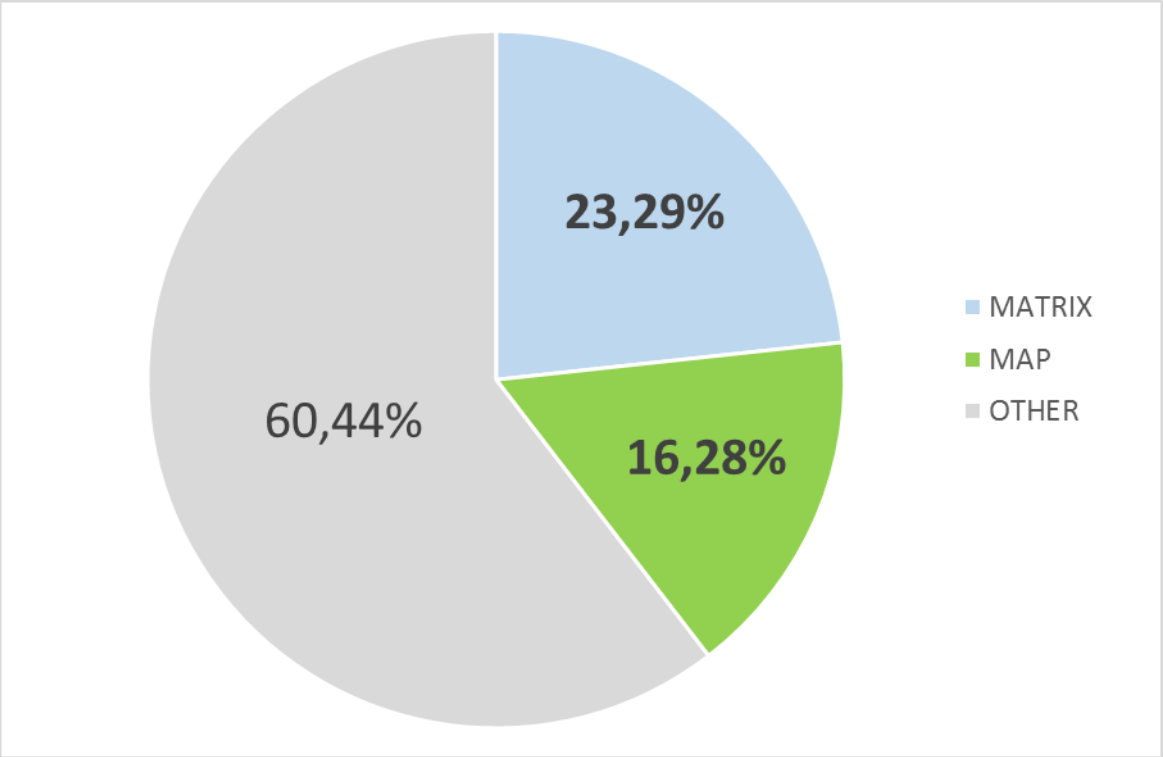


Fig. 37 – *Actual Time Spent in matrices and maps visualization*

This pie confirms and strengthen the evidences shown in the previous figure (*Figure 36*): People spent 23,3% of the overall time of the experiment in watching matrices, and spent only the 16,8% looking at maps.

What does it mean?

As we can see from the previous figures, scenarios 1 and 3 have the highest average amount of time spent: underneath these data, there is the evidence that people spent more time studying scenarios described with matrices.

We can conclude that watching matrices requires more time because of numeric data analysis, meanwhile maps can be seen as an "intuitive tools".

This means that companies should be invited to represent short term scenarios and events -and its related risks- through maps (instead of matrices) in order to reach a quick win solution and optimize decision making process.

In fact, visual design elements of reports, such as graphical displays, are considered to be a form of rhetoric designed to convince the user that management's assertions are truthful[6].

Recent reviews of research related to the effects of information presentation format on decision making suggests that the efficacy of a given format (e.g., graph versus table) depends on task and decision maker characteristics[6].

Tabular representations provide a better fit in terms of minimizing judgment effort and maximizing accuracy for symbolic tasks; graphical representations are a better fit for spatial tasks: this is true for simple data extraction and analysis tasks; however, as task complexity (e.g., the number of alternatives in a problem set or the number of cognitive operations required to make a judgment) increases, cognitive fit depends on judgment strategies[6].

Because graphical displays emphasize an overview of the information, they may be a better fit for less knowledgeable decision makers' information search patterns. On the other hand, tabular formats may be a better fit for more knowledgeable decision makers because they facilitate viewing and acquiring specific details.

Consequently, to study long term scenarios, often characterized by a huge number of data, companies are invited to represent events through matrices: as a matter of facts, this kind of representation is a very structured and precise tool to organize data, through which people can better analyze facts and statistics collected together

Through the last part of the dissertation will be highlighted the numerate people's behavior:

	TIME SPENT (sec)				TIME SPENT (%tot.)			
	MATRIX I	MAP I	MATRIX II	MAP II	MATRIX I	MAP I	MATRIX II	MAP II
User 1	53,787	51,746	76,06	31,106	7,48%	7,20%	10,58%	4,33%
User 2	54	38,422	56,093	21,571	13,11%	9,29%	13,56%	5,22%
User 3	195,457	98,78	64,646	40,489	23,35%	11,80%	7,72%	4,84%
User 4	50,953	30,765	37,976	26,606	14,01%	8,46%	10,44%	7,32%
User 5	46,759	29,978	29,358	28,743	10,43%	6,69%	6,55%	6,41%
User 6	59,052	22,787	67,721	31,61	9,87%	3,81%	11,32%	5,29%
User 7	60,708	48,106	65,828	59,314	10,92%	8,65%	11,84%	10,67%
User 8	68,841	110,059	137,862	82,627	7,37%	11,79%	14,77%	8,85%
User 9	42,089	23,453	29,235	37,099	13,72%	7,64%	9,53%	12,09%
User 10	54,246	49,799	52,621	46,443	14,47%	13,28%	14,03%	12,38%
User 11	52,433	40,646	28,491	24,221	16,81%	13,03%	9,13%	7,77%
User 12	75,893	30,273	40,134	43,987	13,07%	5,21%	6,91%	7,58%

NUMERATE USERS

123 HIGHEST VALUES

Fig. 38 – *Numerate Users' Time Spent*

This table (*Figure 38*) shows time spent in viewing matrices and maps per user.

Matrix I and map I represents, respectively, matrix shown in first scenario and map shows in second scenario. Matrix II and map II represents, respectively, matrix shown in third scenario and map shows in fourth scenario.

In particular, the figure is divided in two parts. The left one, shows time spent, in seconds, watching matrices and maps: e.g., the user 1 spent 53,8 seconds looking at the matrix 1. The right one shows the percentage of overall experiment time spent watching matrix and maps: e.g., user 1 spent the 7,48% of overall experiment time in watching the matrix 1. As you can see, in the left part of the figure there are some values in red: these represents the highest amount of time spent in viewing the single map or matrix (expressed in percentage of overall experiment time spent).

Users 3,5,7,9,10, as previously written, have been classified ad numerate people.

The numerate people's behavior, highlighted in yellow in *Figure 38*, confirms the hypothesis of numerate people's attitude.

In fact, feeling confident with numbers, they spent a higher amount of time watching matrices despite of maps, having a greater mathematical knowledge able to efficiently analyze large amounts of data.

We can conclude that the best graphic representation for a risk assessment depends heavily on the capabilities of the individual considered.

More the student possesses analytical capabilities, the more he or she will be inclined to carry out accurate control of complex data to reach a precise and irrefutable solution.

The less user will have such a kind of knowledge, it will be pushed to a more intuitive and quick analysis in the form of graphical display.

CONCLUSIONS

In recent years, the importance of risk management within companies has grown. Businesses have begun to understand that adequate business risk management can provide the company with added value.

At the basis of this reasoning there is a new way of understanding the risks. This line of thought is based on the idea that risk should not be considered only as a negative element but also as a positive element to be exploited to grow.

Through a careful identification and risk selection process, companies today are able to determine the appropriate level of risk they can incur to grow and become competitive, aligning their business objectives with the level of risk that they choose.

Risk management today is no longer just a phenomenon reserved for listed companies operating in the financial sector, characterized by strong volatility and strong pressure from external, market and financial risks. In fact, today's risk management becomes an integral part of business processes even for other businesses that face each day various kinds of risks.

Despite the growing importance that ERM is gaining in recent years, many businesses are still not convinced of the many benefits of implementing this process. In fact, in Italy, small and medium-sized businesses are still reluctant to adopt such models. At the basis of this choice, however, there are also purely economic and organizational reasons.

The implementation of a proper ERM process requires the investment of relevant resources, both financially and in terms of those involved, with the know-how needed to provide value added to the enterprise. In addition, from an organizational point of view, the creation of this procedure requires the implementation of numerous complex steps aimed at creating a detailed and efficient process.

For these reasons, some companies (especially small and medium-sized) are reluctant to implement an adequate ERM process, lacking often the resources needed to implement this strategy.

To date, numerous solutions are being sought to make business identification and risk assessment processes as logical as possible, to allow a widespread diffusion of such divisions within the international economic context.

Although the basis for such solutions is always statistical models based on complex calculations and the use of specific simulations (quantitative and qualitative models), the key component of risk assessment remains the human component. It is the managers who have this function to have the last words in the decisions to be made.

For this reasons, scientific studies, such as Behavioral Account Research and Neuroaccounting, are now underway to analyze how the psychological and emotional component affects individuals in risk identification and selection processes.

Following this line of thought, several methods have been implemented to analyze the reactions of economic operators to risk management situations.

One of these methods is the one analyzed within the processing, known as eye tracking. Using this technology, it is possible to analyze the visual reactions of subjects during various risk situations in order to analyze physiological and visual reactions to the basis of their choices.

Through the implementation of an experiment with the participation of some MBA students, the author has been able to put into practice what has been said to analyze student reactions in solving specific questionnaires created specifically to assess the capabilities of the Individuals to identify and select different levels of risk.

Thanks to the data obtained from the use of e-tracking in this process, the author has come to interesting conclusions. Specifically, through the provision of graphical and matrix visualizations for risk assessment, it has been found that among the subjects that are most confident with mathematical calculations prefer to analyze scenarios in which there are large quantities of data, to obtain a More accurate vision of the risk level. On the other hand, subjects with lower mathematical knowledge than the previous ones preferred to focus their analysis on graphical representations, providing a faster and more intuitive reading of the data.

Thus, it was possible to reach the solution that at tabular representations provide for better fit in terms of judgment minimizing effort and maximizing accuracy for symbolic tasks; Graphical representations are a better fit for simple tasks.

Because graphical displays emphasize an overview of the information, they may be better fit for less knowledgeable decision makers' information search patterns. On the other hand, tabular formats may be better fit for more knowledgeable decision makers because they facilitate viewing and acquiring specific details.

Consequently, to study long-term scenarios, often characterized by a huge panel of data, companies are invited to represent events through matrices: as a matter of facts, this kind of representation is a very structured and accurate tool for organizing data, through which people Can better analyze facts and statistics collected together.

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ENTERPRISE RISK MANAGEMENT AND MANAGERIAL RISK PERCEPTION: AN ANALYSIS THROUGH EYE TRACKING EXPERIMENTS

SUMMARY

The study of risk in the economic field has been increasingly considered in the last years to help predicting losses and the consequent damage.

Risk is: *A probability or threat of damage, injury, liability, loss, or any other negative occurrence that is caused by external or internal vulnerabilities, and that may be avoided through preemptive actions.*

The definition of risk involves two key aspects:

- Qualitative: the risk can be read as *upside risk* ("uncertain possibility of gain") or *downside risk* ("risk of the actual return being below the expected return, or the uncertainty about the magnitude of that difference"),
- Quantitative: the risk can be read as the quantification of the loss expectation.

The way people react to risks can change the size of its damages. In fact, people can be *risk-averse* or *risk-taking.*

To understand the nature of a risk, it is important to analyze it using three guidelines:

1. What kind of risk is acceptable and how to handle it
2. Which risk must be avoided and how
3. What risk can be predicted and how to manage it

Today, the function of enterprise risk management is very important for the development of an economic society. Anyway, the method still needs improvements. The problems which occurred in the past were in the lack of

separation of different risks management and in the consideration of only the *down-side risks*.

Due to high costs and organizational difficulties, most of Italian small-medium companies choose not to use risk management systems. Market risks, credit and reputation are the biggest concerns in the Italian companies, and represent the main reasons why these firms introduce ERM processes.

Nevertheless, ERM has some limits. These can be brought by wrong choices, errors and malfunctions. The process may also bring to a phenomenon of "risk stress" where managers would have to constantly control every action.

ERM doesn't claim to completely abolish risks. Its purpose is to manage them to achieve results. The system should be coherent to the profile of the society and its degree of *tolerable risk*. Its purpose is to create strategies to manage risks reaching a degree of reasonable certainty. There are four specific goals:

- *Strategic goals*: the ways for the company to create value for its stakeholders.
- *Operational goals*: the ways to achieve adequate levels of performance throughout the company.
- *Reporting goals*: the reporting of the availability of accurate, timely information and its consistence with the prearranged objectives.
- *Compliance goals*: operating policies and procedures which are related to the legislative system of the specific country.

The ERM process is composed of several steps:

1. Strategy and Risk appetite definition
2. Risk assessment, starting from risk identification
3. Reporting on the risk assessment's results
4. Risk treatment

5. Assessment and reporting on residual risks
6. Continuous risk monitoring

The company that makes use of the ERM process must define its *Risk Appetite*, that is the amount of overall risk that the company is willing to take within the limits imposed by its risk capacity, in achieving the goals of business value growth. The company formulates then a *Risk Appetite Statement*.

The other important process to take into consideration is the *Risk Assessment*, whose job is to identify, measure and evaluate the risk events. It can be divided into *identification* phase and *evaluation* phase (*estimation* and *prioritization*).

During the *Risk Reporting* all the risks emerged in the *identification phase* are presented.

If a company should deal with a risk, *Risk Treatment* brings risk back to the limit of risk appetite tolerated by the company. *Risk Treatment* is composed of two methods:

- *Ex-ante procedures*, management operations settled before the risk is manifested,
- *Ex post procedures* which work after the risk is manifested.

When the Risk treatment is over, other analysis and reports are made. There will be internal and external reports.

- Internal reports occur in the organization of the company where each level (board of directors, business unit, individuals) works to manage risks,
- External reports occur when a company informs its stakeholders of the risks.

At the end of the ERM, a *Monitoring Process* checks the results of the entire system. There are two monitoring methods:

- Continuous evaluation,

- Separate assessment: the evaluation is made at fixed intervals.

The measurement of identified risks can be done through three types of techniques:

- *Quantitative*: these techniques are used to determine the distribution of the probability associated with the potential impacts of a risk event.
- *Semiquantitative*: these techniques assign numbers to the categories identified through the qualitative analysis.
- *Qualitative*: these techniques employ descriptive sequences to represent the likelihood and impact of each identified risk.

The risk assessment mainly consists in the estimation of two fundamental parameters defining the risk: the *probability* of manifestation of an uncertain event and the *impact* on the organization's ability to meet the set goals.

In estimating probability and impact, four different measurement scales can be used:

1. *nominal scale*: events are grouped into categories that describe the type without being sorted, graded or assessed (economic, financial, environmental, technological events);
2. *ordinal scale*: it establishes a scale or a certain order of importance, such as high, medium or low, to classify and categorize events in order of significance and according to their likelihood and their impact;
3. *intersperse scale*: the events are sorted according to a precise numerical scale with equal distances between one class and another;
4. *proportional scale* relative to the scale intervals, allows analysts to determine precisely the relationship between events.

Within the generic group of quantitative techniques, it is necessary to distinguish between *non-probabilistic, probabilistic techniques* and *benchmarking*.

Probabilistic techniques suggest a certain distribution of events behaviors. An example of probabilistic technique is the *Value at Risk*. This methodology controls that the variability of expected value does not exceed a certain confidence level over a period.

Non-probabilistic techniques quantify the impact of a potential event on a hypothesis of distribution without determining the probabilities of occurrence, that must be calculated separately.

Finally, *benchmarking techniques* are used to evaluate a specific risk in terms of likelihood and impact and consequently improve response to risk for both sides.

There's also a *semiquantitative approach* which assigns classes identified through qualitative assessments of numbers at each level of probability and impact identified, allowing the company to assess risks using a score, called *risk score*.

Regarding the *Qualitative Techniques*, the best known is the "*probability-impact matrix*". In this case, the evaluation is carried out by considering together the two parameters defining risk, probability of manifestation and expected impact, which are estimated by subjective evaluations.

The probability-impact technique requires the definition of:

- A qualitative scale representing the probability of the adverse verification;
- A qualitative scale representing impacts/ economic consequences of the event;
- A qualitative scale assigning each combination of probability and impact a rating, called *risk rating*;
- A qualitative scale of the risk rating evaluation criteria, that is an indication of the attitude against a risk that has a certain risk rating

The image below provides an example of a qualitative P-I Matrix.

		Impact				
		Insignificant	*Low*	*Moderate*	*High*	*Catastrofic*
Probability	*Sure*	High	High	Extreme	Extreme	Extreme
	Probable	Moderate	High	High	Extreme	Extreme
	Moderate	Low	Moderate	High	Extreme	Extreme
	Improbable	Low	Low	Moderate	High	Extreme
	Rare	Low	Low	Moderate	High	High

Legend
Impact
Probability
Risk Rating

Qualitative description

Probability	*Sure*	High likely to happen event, which probabiliy it up to 50%
	Probable	Quite likely to happen event, which probability is from 20% to 50%
	Moderate	Low likely to happen event, which probability is from 5% to 20%
	Improbable	Unlikely to happen event, which probability is from 1% to 5%
	Rare	Very unlikely to happen event, which probability is not upper than 1%

Impact	*Insignificant*	Negligible economic effects on the company
	Low	Low economic effects on the company
	Moderate	Moderate economic effects on the company
	High	High economic effects on the company
	Catastrofic	Disastrous effects on the company

Risk Rating	*Extreme*	Underlights the need of immediate risk management actions
	High	Underlights an accurate risk evaluation from CRO
	Moderate	Underlights a risk evaluation from line manager
	Low	Underlights day by day procedures

As a matter of facts, the probability-impact matrix can be also seen as a semi-quantitative tool. In fact, the semi-quantitative risk matrix is used for *quantitative measurement of likelihood* and *qualitative judgement of consequences*.

Levels of severity and probability.

Severity	Scale	Description	Probability	Description
Critical	4–5	Cannot achieve key term or major program milestone	0.00–0.10	Remote
Serious	3–4	Major slip in key milestone or critical path impacted	0.10–0.40	Unlikely
Moderate	2–3	Minor slip in key milestones and not able to meet need dates	0.40–0.60	Likely
Minor	1–2	Additional resources required but able to meet need dates	0.60–0.90	Highly likely
Negligible	0–1	Minimal or no impact	0.90–1.00	Near certainty

Critical	M	H	H	H	H
Serious	M	M	M	H	H
Moderate	L	M	M	M	H
Minor	L	L	M	M	H
Negligible	L	L	L	M	M
Origin	0.00~0.10	0.10~0.40	0.40~0.60	0.60~0.90	0.90~1.00

The problem of managerial risk perception can be analyzed according to the behavioral habits, emotions, feelings, culture and other elements which influence the human psyche and can so influence people's actions within a business environment.

In the accounting process, people can be considered as the actors of the economic process: accounting can be altered by the effects of collective and individual behaviors.

Behavioral accounting can be considered as the application of the behavioral sciences to accounting. The purpose of the study is to analyze the decision-making process through the behavioral sciences.

Many other fields can help in the research: psychology, psychiatry, political science, sociology, anthropology and so on. It's clear that BAR is considered an interdisciplinary field of study.

The union of economics, psychology and neurobiology led to a new study called Neuroeconomics. Neuroeconomics analyzes the process that influences decision making from a neurobiological point of view.

This study, and Behavioral Accounting Research as well, have an important starting point, that breaks through the boundaries of classic theories: theorists should stop thinking about people's brain as a "black box" and try to explore it.

The research in Behavioral accounting has met many difficulties over the years as it hasn't been much considered by scholars. According to Basu, this research was "predominantly conducted in an ivory tower with little connection to problems faced by practitioners". The system itself still lacks experimentation and innovation.

Recent studies use neuroscience tools (such as fMRI, EEG and Eyetracking) to investigate more directly on how brain behavior reflects economic decisions and how the brain responds to profit and losses.

Neuroscientists have observed the brain during the process of earnings and returns. In particular, researchers have measured the brain behavior using BOLD technique (*blood oxygen level dependent*). The results are relevant in the correlation between earnings and the activity in the ventral striatum. The reaction of the brain is more relevant when facing a loss. This suggests there is a link between the brain's activity and positive/negative aspects of accounting, in general, of company performances.

The eye tracking methodology focuses on the eye fixation and saccades (eye movements) when an individual is processing an economic decision, to measure the user's economic behavior. Using this tool, Neuroeconomics aims to study the relation between the visual input process and the decision-making process.

It is sure that the eye movement is linked to attentions and behavior. The *gaze*, the changing of direction, could mean the rise or the decrease of attention.

Individuals may observe what interests their attention and this could lead to a choice. Eye movement researchers aim to understand the relation between eye shifts and cognitive process.

Visual attention can be:

1. *Orienting*, which focuses on the center of the attention
2. *Detecting*, which focuses on the context.

The three types of movements that are relevant in the attention process are *saccades*, *fixations*, and *pursuits*.

Fixations show the attention to an object of interest, whereas saccades show the need to change the direction of the attention. Gaze is involved directly in the decision formation.

The eye tracking technology measures the direction of visual attention and the relation between the gaze and the pupil dilatation. It indicates what a person is looking at and so his attention, but also the time he looked at a certain point, the blinks, the pupil dilatation and saccades.

There are many eye-tracking methods. The most used ones are those that study the eye movements while people are using a computer – this is also the methodology used during the managerial risk perception experiment. They focus on the gaze direction, the eye position and the pupil dilatation.

An innovative tool in the eye tracking technology is the Tobii device. The Tobii eye tracker consists in a lightweight machinery composed by complex algorithms and sensors. It can calculate the position of the eyes and the pupil size in order to study the emotional reactions and so the economic decisions origins.

To move from theory to practice, the author of the thesis has set up an experiment to test what has been said so far, using eye tracking technology. The experiment's starting point was the willingness to analyze managerial risk perception, studying if different representations of the same pattern could affect economic decisions. This scientific research employed a cluster of 12 MBA students. In fact, to complete the experiment, the author needed the collaboration and availability of people who has a managerial smattering which enables them to understand business patterns: the assessment consisted in considering a series of dimensions like economic, financial, reputational, regulatory, etc. and people had to act like an operations manager.

The experiment was articulated in two phases:

1. People were asked to complete a short paper questionnaire in which they should solve mathematical and statistic problems without using a calculator.
2. People were asked to analyze some risk maps, matrices and the probability of some risk events and then to conduct a risk assessment based on the information provided. In this phase, we employed the eye-tracking device.

The author asked to fill paper questionnaires to analyze students' attitude to mathematics and scientific calculation, the so-called *numeracy skill*.

Being numerate means having the confidence and skill to use numbers and mathematical approaches in all aspects of life - at work, in practical everyday activities at home and beyond, as consumers, in managing our finances, as citizens understanding the world about us, and so on.

During the second phase, people were asked to see a slideshow, in which they should look at four different scenarios: each one was characterized by the presence of a different graphic representation (matrix or map).

People's task was to answer the questions that will appear at the end of every experiment.

The goal of first phase was to show and analyze the paper questionnaire answers, in order to individuate who has the highest numeracy skill. Feeling more confident with mathematics, and, in general, with numbers, numerate people were expected to pay attention on matrices to better understand patterns.

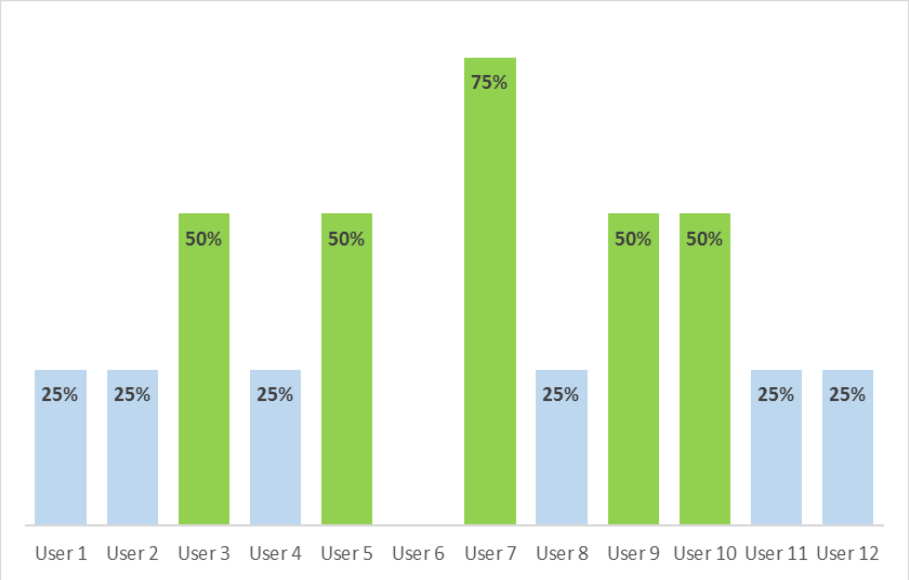
The *phase I* output served to highlight if people who have outstanding numeracy skills actually focused their attention on matrices instead of maps.

Using the cognitive theory, it's possible to say that a user's reliance on graphical displays of various informations depends on task complexity and his or her level of task-specific knowledge and experience.

"Nonprofessional" users tend to have lower levels of task-specific knowledge and experience, they relied on these graphical displays to reduce cognitive effort when making risk evaluations and judgments, regardless of task type.

On the other hand, "professional" users don't rely on graphical displays when engaged in the -relatively simple- task of evaluating current year earnings performance. They will rely on these graphical displays to reduce cognitive effort only when performing the more complex tasks of making judgments.

The analysis of people's answers to the paper questionnaire highlighted that the 40% of people can be defined numerate: in fact, they did at least 50% of correct answers with an average filling time of 8 minutes (see Figure below).

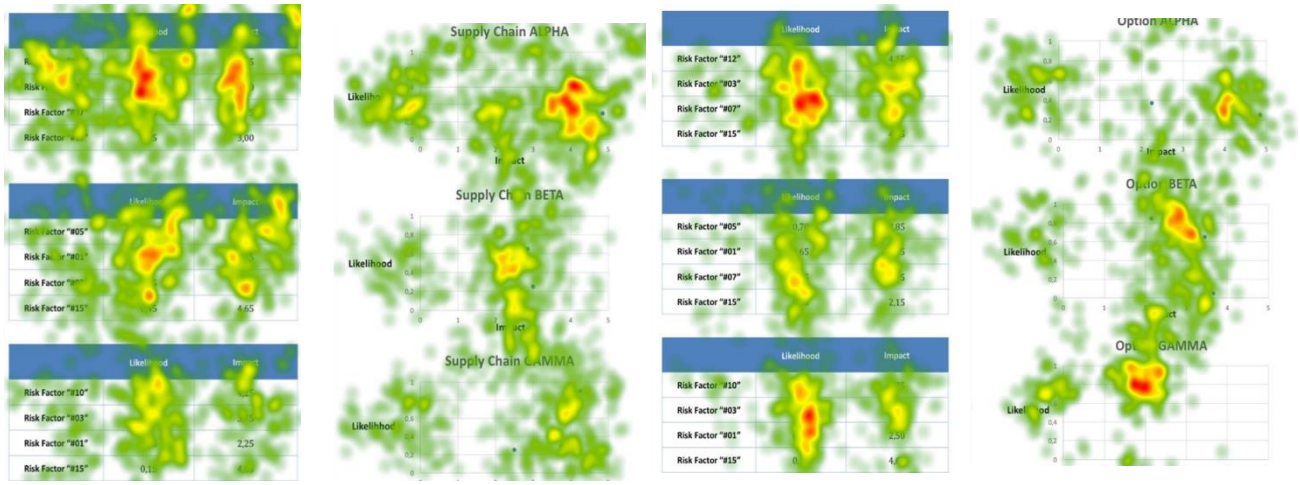


As said previously, during the *phase II* students were employed in eye tracking experiments.

Watching the slideshow, people should look at four different scenarios.

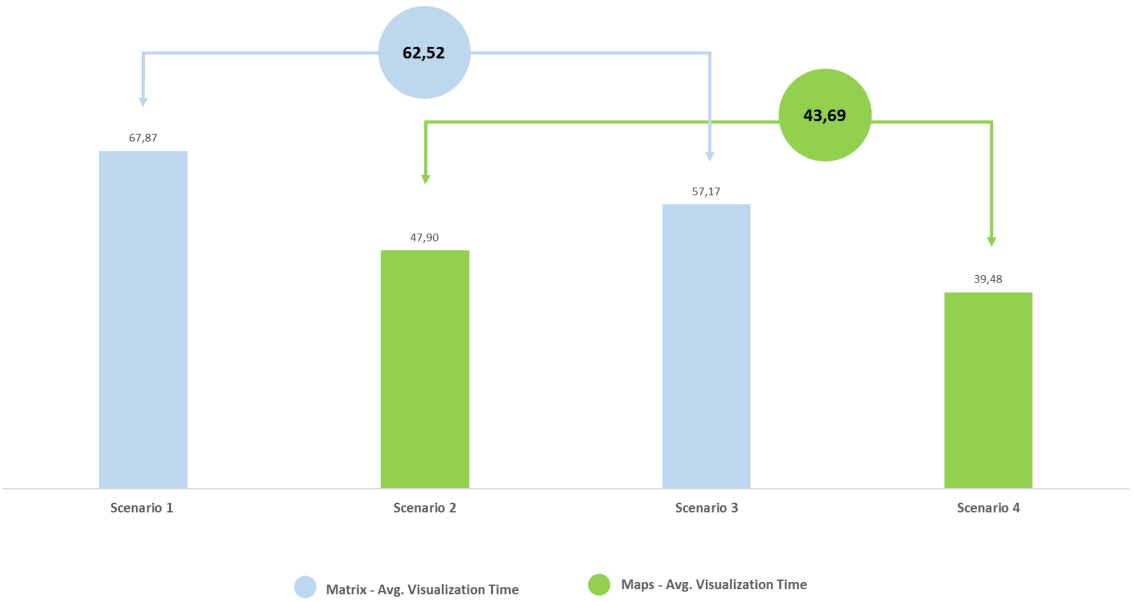
These scenarios described four different business situation: per each scenario, users were asked to look at 3 different options, choosing the riskier one (risk evaluation process). It must be noted that scenarios were represented by maps and matrices.

Analyzing the heatmap charts (see figure below) obtained by the eye tracking technology, we can conclude that people had chosen the options watched for longer: in the whole four scenarios, users focused their attention on figures corresponding to options they felt riskier.



The results from the analysis of the four scenarios provided another interesting point of view. The students' answers appeared to be more homogeneous in the analysis of data represented in graphic form rather than in matrix form. This assumption may be related to the fact that the graphic representation provides to the viewer the ability to quickly and easily perceive the answers he thinks are right, unlike the matrices require a more careful and accurate analysis.

The graph below shows trends of time spent watching the scenarios (in seconds). As can be seen, the total amount of time spent watching matrices (corresponding to scenarios 1 and 3) is 62, 52 seconds, and the total amount of time spent watching maps (corresponding to scenarios 2 and 4) is 43,29: almost 20 second less.



Scenarios 1 and 3 had the highest average amount of time spent: underneath these data, there is the evidence that people spent more time studying scenarios described with matrices.

We can conclude that watching matrices requires more time because of numeric data analysis, meanwhile maps can be seen as "intuitive tools".

This means that companies should be invited to represent short term scenarios and events -and its related risks- through maps (instead of matrices) in order to reach a quick win solution and optimize decision making process.

In fact, visual design elements of reports, such as graphical displays, are considered as a form of rhetoric designed to convince the user that management's assertions are truthful, and fits better with quick wins.

Consequently, to study long term scenarios, often characterized by a huge number of data, companies are invited to represent events through matrices: as a matter of facts, this kind of representation is a very structured and precise tool to organize data, through which people can better analyze facts and statistics collected together.

So, answering to the question whether graphical format affects decision making, this hypothesis should be confirmed.

Recent reviews of research, related to the effects of information presentation format on decision making, suggest that the efficacy of a given format (e.g., graph versus table) also depends on task and decision maker characteristics.

Graphical displays emphasize on overview of information, so these may be a also better fit for less knowledgeable decision makers' information search patterns. On the other hand, tabular formats may be a better fit for more knowledgeable decision makers because they facilitate viewing and acquiring specific details.

Through the last part of the dissertation will be highlighted the numerate people's behavior:

	TIME SPENT (sec)				TIME SPENT (%tot.)			
	MATRIX I	MAP I	MATRIX II	MAP II	MATRIX I	MAP I	MATRIX II	MAP II
User 1	53,787	51,746	76,06	31,106	7,48%	7,20%	10,58%	4,33%
User 2	54	38,422	56,093	21,571	13,11%	9,29%	13,56%	5,22%
User 3	195,457	98,78	64,646	40,489	23,35%	11,80%	7,72%	4,84%
User 4	50,953	30,765	37,976	26,606	14,01%	8,46%	10,44%	7,32%
User 5	46,759	29,978	29,358	28,743	10,43%	6,69%	6,55%	6,41%
User 6	59,052	22,787	67,721	31,61	9,87%	3,81%	11,32%	5,29%
User 7	60,708	48,106	65,828	59,314	10,92%	8,65%	11,84%	10,67%
User 8	68,841	110,059	137,862	82,627	7,37%	11,79%	14,77%	8,85%
User 9	42,089	23,453	29,235	37,099	13,72%	7,64%	9,53%	12,09%
User 10	54,246	49,799	52,621	46,443	14,47%	13,28%	14,03%	12,38%
User 11	52,433	40,646	28,491	24,221	16,81%	13,03%	9,13%	7,77%
User 12	75,893	30,273	40,134	43,987	13,07%	5,21%	6,91%	7,58%

NUMERATE USERS

123 HIGHEST VALUES

The table above shows time spent in viewing matrices and maps per user.

Matrix I and map I represents, respectively, matrix shown in first scenario and map shows in second scenario. Matrix II and map II represents, respectively, matrix shown in third scenario and map shows in fourth scenario.

The figure is divided in two parts. The left one, shows time spent, in seconds, watching matrices and maps: e.g., the user 1 spent 53,8 seconds looking at the matrix 1. The right one shows the percentage of overall experiment time spent watching matrix and maps: e.g., user 1 spent the 7,48% of overall experiment time in watching the matrix 1. As the reader can see, in the left part of the figure there are values in red: these represents the highest amount of time spent in viewing the single map or matrix (expressed in percentage of overall experiment time spent).

Users 3,5,7,9,10, as previously written, have been classified as numerate people.

The numerate people's behavior, highlighted in yellow, confirms the hypothesis of numerate people's attitude.

In fact, feeling confident with numbers, they spent a higher amount of time watching matrices despite of maps, having a greater mathematical knowledge able to efficiently analyze large amounts of data.

From the last analysis conducted, we can conclude that the best graphic representation for a risk assessment also depends on the capabilities of the individual considered -and not just on graphical displays.

The more businessman possesses analytical capabilities, the more he or she will be inclined to carry out accurate control of complex data to reach a precise and irrefutable solution.

The less user will have such a kind of knowledge, it will be pushed to a more intuitive and quick analysis in the form of graphical display.

From the analysis of the results obtained through the experiment, a specific conclusion can be reached. The graphical data representation allows a risk perception more intuitive and quick, which is manifested with a homogeneity of the results proposed by the individual respondents. On the other hand, a matrix representation forces subjects to carry out a more detailed analysis, the result of which will depend on the mathematical abilities of the subject. In summary, therefore, risk perception is strongly influenced by the typology of representation,

since a graphical representation can, on the one hand, create homogeneity of the results, but it can never be as accurate as the analysis of mathematical calculations made on matrix data, which, in turn, will depend on the analyst's numeracy.