Open University Cyprus **Hellenic *Open University***

Master's join degree/post graduate Programme
Enterprise Risk Management (ERM)

MASTER THESIS

Risk Perception and Human Error Risk Management in Investment Banking

Κάκια Οικονομίδου

Επιβλέπων Καθηγητής

Αντώνης Ταργουτζίδης

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Περίληψη

Ο κύριος στόχος αυτής της μελέτης είναι να παρέχει μια ανάλυση της αντίληψης του κινδύνου και της διαχείρισης του κινδύνου ανθρώπινου σφάλματος στον τομέα της διαχείρισης επενδύσεων και συγκεκριμένα στη διαχείριση χαρτοφυλακίων. Διεξήχθη μια πιλοτική μελέτη σχετικά με την ανάλυση κινδύνου ανθρώπινων παραγόντων με βάση το σύστημα ταξινόμησης GEMS του Reason, όπου ένα ερωτηματολόγιο έρευνας αποστάλθηκε σε δύο συνεντευξιαζόμενους, προκειμένου να ανακαλύψει τις απόψεις τους σχετικά με τα καθήκοντα διαχείρισης του χαρτοφυλακίου και τα πιθανά ανθρώπινα λάθη που προκύπτουν, την πιθανότητα και την επίδραση αυτών των λαθών. Όπως προκύπτει από αυτή την πιλοτική μελέτη, τα περισσότερα ανθρώπινα λάθη είναι βασισμένα σε δεξιότητες, πράγμα που σημαίνει ότι οι άνθρωποι είναι επιρρεπείς ολισθήματα/ παραστρατήματα (slips and lapses) στα συνηθή καθήκοντα.

Summary

The main goal of this study is to provide an analysis of the risk perception and human error risk management in investment management sector and specifically in portfolio management. A pilot study on human factors risk analysis was conducted based on Reason's GEMS classification scheme where a survey questionnaire was sent to two interviewers in order to find out their views on portfolio management tasks possible human errors, the likelihood and the impact these errors may have. As it appears from this pilot study, most of the human errors are skill-based, which means that humans are prone to slip and lapse with familiar tasks.

Acknowledgement

Firstly, I would like to thank my supervisor Mr Antonios Targoutzides for his expertise, guidance and encouragement throughout the process of writing this thesis.

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Risk perception and human error risk management in investment management sector.

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Chapter 1

Introduction

Although human error is something that lies in all the common sectors and everyday processes. studies have been mainly developed only in safety critical sectors.

The term ‘‘human factors” refers to the behaviour of humans affecting any risk and has 2 levels, risk perception -intentional behaviour and human error -unintentional behaviour (Targoutzidis et. Al.2009). Human error is an important aspect that needs to be counted when designing and risk assessing large complex systems, especially when human is an important part of the system.

Risk perception research is an enlightening path to understand how risks are processed by individual people. It stated that when interpreting events, someone includes the situational circumstances, the organizational structure, the social and political context, and cultural values into the perception and evaluation of the risk involved (Zwick et al 2002: 2).

All intended and unintended human behaviours in an organization can cause Operational Risks. Firms are interested in operational risk because exposure can be critical.

There is a range of definitions to describe Operational Risk but based on the work of Moosa 2008, we classify them as follow (Moosa 2008: 87-88):

i) ‘‘*All types of risk other than credit and market risk”.*

(ii) ‘‘*The risk of loss due to human error or deficiencies in systems or controls”.*

(iii) ‘‘*The risk that a firm’s internal practices, policies, and systems are not rigorous or sophisticated enough to cope with unexpected market conditions or human or technological errors”.*

(iv) ‘‘*The risk of loss resulting from errors in the processing of transactions, breakdown in controls, and errors or failures in system support”.*

According to Basel Committee, Operational risk is defined as ‘‘the risk of loss resulting from inadequate or failed internal processes, people and systems or from external events’’. The definition includes human error, fraud and malice, failures of information systems, problems related to personnel management, commercial disputes, accidents, fires and many others.

If the human factors which influence employees are understood, organisations will be able to implement targeted solutions to reduce error, mitigate its consequences and improve human reliability.

People's risk can range from simple errors, such as staff clicking on a virus-infected email, to lack of skills, strategic miscalculations, poor succession planning or even deliberate acts of sabotage or fraud.

Making errors is part of the human nature but by building an operational risk management framework that goes beyond compliance, an investment organization as well as any organization can rule operational risk incidents by actively reducing their likelihood or impact. As Leaver suggests, culture measurement and change has previously been identified as crucial for restoring trust, improving Risk Management and avoiding future failures in financial institutions (Leaver et al, 2019).

As it looks, one of the main components of operational risk that is common to all organisations is human factors. The aim of this Thesis is to analyse the effects of human factors (human error and individual risk perception) on the risk management of the financial sector and more specifically on the field of investment management. This will be conducted by identifying intended and unintended erroneous transactions of the investment/portfolio managers.

This analysis will combine the research topics of subjective risk perceptions and human error, applied on investment management.

1.1 Human Factors

According to International Ergonomics Association, the term human factors (or ergonomics) is defined as ''*the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance*'' (IEA,2019). In simple words is how humans behave physically and psychologically in relation to particular services, environments or products.

The identification and management of human factors is important for the effective and reliable minimisation of risk in any organization dealing with any activities.

Human factors (ergonomics) promote a holistic approach which considers physical, cognitive, social, organizational, environmental and other relevant factors. The organisational factors have the greatest influence on individual and group behaviour. They include organisational priorities, structures, policies, and processes, decision-making and strategy, the culture of the company or team, the availability of resources, communication systems, change management, leadership behaviour, and relevant Key

Performance Indicators. The culture needs to promote employee involvement and commitment at all levels (HSE 2017, IEA 2019).

The job factor is about the task requirements that should be designed in accordance with ergonomic principles to take into account limitations and strengths in human performance. Moreover, it includes the importance of the physical working environment, the human-machine interface, the availability and quality of procedures.

Another crucial point is the mental match of the job and the person, that is cognitive ergonomics. It is concerned with the individual's mental processes, such as perception, memory, reasoning, and motor response, as they affect interactions among humans and other elements of a system. Moreover, it includes mental workload, skilled performance, information and decision-making requirements, human-computer interaction, human reliability, work stress and training as these may relate to human-system design. Any mismatches could lead to potential human error (HSE2017,IEA2019).

The individual factor is about the personal attitudes, competence and skills, habits and personalities, moods, attitudes, mental abilities and even personal health issues. Depending on the task demands, all these individual characteristics influence someone's behaviour in complex ways, either in good or a bad way.

In general, there have been several approaches for human error, each one of them including separate models. Although assigning one model to one approach or the other includes some subjectivity and can be different between different literature reviews, the following approaches are the most dominant:

- Behavioral approach. According to this approach human reliability is inherently variable and can be measured and modelled in a stimuli-response model. The aim is to create curves that indicate human error probability and to focus on recovery, as human error is unavoidable.
- Ergonomic/contextual approach. According to this approach an error is simply a result of the context where it takes place. By modelling the effect of each contextual factor (Performance Shaping Factors – PSF) on error, one can model its occurrence.
- Cognitive approach. This approach focuses on the operation of human mind and possible errors that can be created during this operation. Its model is stimuli-organization-response (S-O-R) and considers human error as a result of certain cognitive processes. A particular part of this approach is information processing, according to which, human error is the result of inadequate processing of information, or mismatch between the capacity of the operator and the requirements of the system. It focuses on the communication and processing of information.
- Socio-technical approach. According to this approach, human error takes place in a collective context and should be examined taking it into account, rather than focusing on operation of individuals. The reliability of a team is not considered as

equal to the reliability of each one of its members. It focuses on social interaction and collective errors.
- Second generation models. These models actually try to combine many of the models of previous approaches, aiming to provide a more global approach to human error, both in the individual and collective level.

In the same direction, risk perception models can also be classified in certain approaches:

- Behavioral approach. Models of this approach mainly consider risk perception as a result of "black-box" stimuli-response process. Therefore, they try to model the perception of risk by individuals according to similar observations.
- Cognitive approach. According to this approach, risk perception is a result of the cognitive process of humans and therefore focuses on cognitive mechanisms and heuristics in order to model it.
- Socio-cultural approach. According to this approach, risk is perceived in a collective context and interaction among members of a team is very important for the perception of the risks they face. This approach focuses on such interactions.

1.2 Investment Management

Investment management is an area of finance that covers the professional management of different securities and assets, such as bonds, shares, real estate and other securities. Some other terms that are usually used to describe this zone, is portfolio management, asset management, wealth management, money management (Epstein et al, 2009).

The process of investment management involves 5 steps: 1) setting investment objectives, 2) establishing an investment policy, 3) selecting a portfolio strategy, 4) constructing a portfolio and finally 5) evaluating performance (Fabozzi et al 2009: 577).

In simple words the business of investment management is about investing other people's money and one could say that it is the "buy side" of the broader financial industry. The services of investment management can be used by a wide range of organisations and people. These range from a 'retail investor' - a member of the public - whose goals will be savings-related, focusing on retirement, saving for children, wealth transfer and legacy planning, all the way through to very large institutions and governments (Maginn et al, 2018).

Investment fund managers can be employed by investment banks, investment and asset management companies, stockbrokers, insurance and life assurance companies and banks.

Typical tasks include (Lawrence, 2013):

- Direct Client Investment Activities

The main role of a portfolio manager is guiding client investment activities for stocks, bonds, and securities within a particular fund. Fund managers conduct analysis to determine the securities providing the greatest return on investment and mitigating client risk. They may also manage fund activities by deciding which securities to incorporate into the fund's mix of products.

- Provide Investment Advice

Portfolio managers provide investment and financial management advice to their clients and to other financial professionals by advising on long-term strategies for financial management and explain to clients how a particular fund fits into their overall goals.

- Monitor Fund Performance

Portfolio managers monitor the performance of the funds that they manage for their clients targeting their growth. They may focus on one particular fund or manage a suite of financial products. Many fund managers conduct weekly meetings to assess fund performance and identify shortcomings, developing strategies to offset losses and drive profitability. Fund managers also take corrective actions to improve fund performance since they will be judged by how well their fund performs.

- Complete Financial Transactions

Portfolio managers also complete financial transactions on behalf of their clients and the funds they manage like buying and selling stocks, bonds, and securities or even complex transactions to drive profitability or reduce risk. Fund managers weigh the risks and benefits of each transaction and decide if they fit into their client's fund's strategies.

- Maintain Portfolio Records

While conducting investment and oversight activities, fund managers maintain records and documentation related to investments and transactions. The funds are designed with different strategies and objectives and have different risks, policies and expenses thus they should be clearly outlined to clients and regulators. Fund managers may develop weekly, quarterly, or annual reports on fund performance, along with reports of their activities related to managing the fund. They must ensure that all the documents completed are filed and distributed as regulations require

- Ensure Adherence to Financial Regulations

Portfolio managers also ensure that their investment activities operate in accordance with regulations outlined by authorities of financial industry, conducting audits to prevent fraud and ensure that they are not putting client investments at risk unnecessarily. They also submit documents and reports to oversight bodies or appear before regulators to explain decisions they make regarding fund management.

1.3 Thesis format

The main objective of this Thesis is to provide an analysis of the risk perception and human error risk management in investment management sector and specifically in portfolio management. The available literature on this topic will be searched through the procurement of articles, research reports and the consultation of several web sites.

The aim of the Thesis will be pursued through a pilot study on human factors risk analysis in the portfolio management sector. The raw data will be collected through interview schedules among stakeholders of the portfolio management industry. A list of possible human errors in some tasks of portfolio management and the conditions under which these might occur, will be given to interviewers in order to express their views on the probabilities and the impact of these errors.

Chapter 1 (introduction)will be divided into 3 subchapters. At first the concept of human factors and human error will be presented whilst risk perception is intentional behaviour and human error is unintentional behaviour. It also considers the implications of human factors and human error in general.

Subchapter 1.1 Human Factors describes deeper the meaning and the Human Factors. It presents the definition of the term human factors and their importance. Subchapter 1.2 Investment Banking describes the sector. It presents the processes of investment banking, its task and what exactly is that investment bankers do. Subchapter 1.3 aims to explain the format of the Thesis, how is going to be completed, the relevant steps and the description of every chapter.

Chapter 2 conducts a systematic Literature Review and it is divided into 6 subchapters. In Subchapter 2.1 the concept Human Error – Unintentional Behaviour is explained, focusing on Rasmussen's (1982) famous human error taxonomy in which human behaviour can generally be broken down into three separate categories, skill-based, rule-based and knowledge-based behaviour (SRK).

Subchapter 2.2 – Human error models, focuses on the explanation of some first generation and second generations models. Special emphasis is given to Reason's GEMS model since it is the chosen one for this study. GEMS is a classification scheme which facilitates the detection of error and its correction as well as providing help for mitigation measures. Subchapter 2.3 provides literature on Human error in Financial

industry although empirical research of Human error theories in finance sector is lacking.

Subchapter 2.4 focuses on the theories of Risk Perceptions and 2.5 provides some Risk Perception models. At the end Subchapter 2.6 provides some literature on the view of Risk Perception in the financial industry.

Moving on to Chapter 3 Methodology, consists of 4 subchapters. Firstly 3.1 is discussing the chosen GEMS model and presents Reason's error mode Table which lists the potential forms of errors and the related conditions for each level of performance. This table is important since the questionnaire that will later be given to the interviewers, will depend on this Table.

Subchapter 3.2 presents the Data collection instruments of the Thesis, which in this case will be interview schedules. Moreover, chapter 3.3 discusses Data Analysis and Presentation. It consists of a Probability impact matrix on the likelihood and severity of risk categories (the errors) identified by the interviewers. At the end, Subchapter 3.4 is about the ethical considerations of this pilot study.

Chapter 4 – Results, which consists of 3 subchapters. Subchapter 4.1 introduces the portfolio management process, the 3 steps and the various tasks as they will be derived from the interviews and the literature. In Subchapter 4.2 – tasks, conditions and errors- a list of possible human errors on some of the many tasks of the Planning and Execution steps of Portfolio management process are formulated. The list will be based on Reason's list of potential forms of errors and the related conditions for each level of performance. Subchapter 4.3 is Answers results/analysis, where the list of errors/conditions is presented to the interviewers who will be asked whether they agree with those and to also rate occurrence and severity for each error. A brief description of the scores of each interviewer follows as well as a table with the measures against these errors.

Finally, Chapter 5 is the conclusion, where the importance of the Thesis is presented, in terms of how it might help and the measures against each case of human error as well as a discussion about the findings of the Thesis.

Chapter 2

Literature Review

2.1 Human error –unintentional behaviour

Human error is a matter that concerns almost every profession and industry in our times. Reason summarized a great deal of research on human error the past years. He explains that '' Error will be taken as a generic term to encompass all those occasions in which a planned sequence of mental or physical activities fails to achieve its intended outcome, and when these failures cannot be attributed to the intervention of some chance agency'' (Reason, 1990)

Human error deals with types of mistakes that everyday people can make when performing various types of tasks. For Hansen the term human error consists of the "*characteristics of human beings that involve unintentional deviations from what is correct, right, or true*" (Hansen 2006 :64). Strauch also agrees that human error as is *" an action or decision that result in one or more unintended negative outcomes"* (Strauch 2002: 21).

The concept of Human error cannot easily be defined. As Massaiu notes, it applies to a great range of actions like simple tasks, cognitive operations and motor-skills, it can be attributed to a host of different causes like internal constitution, external conditions, task demands, volitions and it can be judged with different criteria e.g. system parameters, agents' intentions, social norms (Massaiu 2005:2). Therefore, it is not an easy task to conceptualize" human error" in just a simple definition including all the possible conditions and fields of application. However psychological and behavioural theories have proven to remain the basis for human error theory.

According to Reason, there are two main approaches for understanding human error – the person approach and the system approach. The person approach focuses on the unsafe acts and errors of individuals through a focus on breakdowns on cognitive processes such as inattention, forgetfulness and behaviors, such as negligence and recklessness. The systems approach acknowledges human fallibility and that errors occur even in the best organisations. From this perspective, human error is a symptom or consequence rather than a cause and this approach focuses on those organizational processes that influence human errors (Reason, 2000).

The goal of human factors is to reduce human error and it consists of numerous disciplines like behavioural, psychology, system, software and usability engineering, social, cognitive science etc.

According to Wickens ergonomics is "*The systematic application of knowledge about the psychological, physical, and social attributes of human beings in the design and use of all things which affect a person's working conditions: equipment and machinery, the work environment and layout, the job itself, training and the organization of work*" (Wickens et al, 1998). In other words, human errors within the ergonomic approach are considered a result of the connection between workers and their environment or system.

Imada in his research describes that human errors within ergonomic approach might occur in three dimensions. Firstly, the Situation based errors related to the immediate work environment in time and space like complicated workstation, wet work surface. Then the Management based errors like failures in communication, leadership, failure to train people, rewards system. Lastly Human based errors, those related to emotional states, morale, motivation (Imada, 1998).

Psychological and behavioural theories have proven to remain the basis for human error theory (Wason et al, 1972). When it comes to the human mind, its cognitive function is a very complex system. According to Manchi, the human cognitive functions uses processes that make the person amazingly fast, to respond flexibly to new situation and to juggle several tasks at once. Unfortunately, though, the thinking process itself is producing occasional inevitable errors (Manchi et al, 2013).

One of the most broadly known and accepted cognitive human error taxonomy is the one of Rasmussen (1982) framework, in which human behaviour can generally be broken down into three separate categories, skill-based, rule-based and knowledge-based behaviour (SRK). The terms skill, rule and knowledge-based information processing refer to the degree of conscious control exercised by the individual over his or her activities.

In Skill based performance the behaviour is ruled by preprogramed instructions developed by either training or experience and is less dependent upon external conditions (Reason,1990). Examples of typical everyday skill performance actions are driving, taking a shower or keyboarding, controlled unconsciously by human instinct. A person is familiar when performing these actions because of the high level of practice, which does not involve conscious control and decision making (Saptari et al, 2015).

Skill based errors may occur because of slips (an action not carried out as intended) or because of reversion once a certain pattern of behaviour has been established but is no longer appropriate.

Rule-based behaviour emphasises the use of procedures and rules when a person must perform known tasks. When people have to consider some changes in the situation, they

turn to rule base performance since they need to modify their largely pre-programmed behaviour. A person may use some conscious thinking in this case to verify whether or not this solution is appropriate whilst ‘’*the goal in rule-based performance is to improve one's interpretation of the work situation so that the appropriate response is selected and used*’’ (DOE,2009). In other words, the individual must diagnose the situation and choose the correct response from a prescribed list of available responses, according to rules.

Errors may occur due to the use of the wrong rule or procedure or maybe due to their faulty recall by an employee. The dominant error mode is misinterpretation and errors arise if an incorrect diagnostic rule is applied that leads to inappropriate actions. It is also possible that someone overuse diagnostic rules that have previously been successful and thus these ‘strong’ rules are usually the first to be applied, even if they are inappropriate (Embrey, 2005).

Knowledge-based performance is about people who are unsure what to do. Basically, Knowledge based behaviours are person’s responses to unfamiliar situations where no skills or rules are recognizable to him. According to Wachter, a person ‘’*must rely on his understanding and knowledge, perceptions of present circumstances, similarities to previous circumstances, and the scientific principles and fundamental theories related to the perceived situation*’’ (Wachter et al, 2013). In other words, the individual must not only diagnose, but also to create a suitable response, as there is no prescribed response for the situation.

At the knowledge-based performance level, errors are related to incomplete or incorrect knowledge or interpreting the situation incorrectly (Reason, 1990). As Embrey notes, for Knowledge based mistakes factors arising from the significant demands on the information processing capabilities of the individual that are necessary when evaluating a situation from first principles, are important. Based on the demands ‘’*it is not surprising that humans do not perform very well in high stress, unfamiliar situations where they are required to ‘think on their feet’ in the absence of rules, routines and procedures to handle the situation*’’ (Embrey, 2005).

What is important to be distinguished is that when using the term human error in this essay, we mean the things that go wrong unintentionally, by accident and that the human did not intend the actions or its resulting outcome. Another important notice is that no amount of training, oversight, coaching, incentive, or punishment, will ever eliminate human error.

2.2 Human Error models

In order to identify some of these human errors and thus mitigate or eliminate them, the use of a technique called Human Reliability Analysis (HRA) is needed. Human Reliability Analysis or Assessment is the term that espouses qualitative and quantitative techniques used to evaluate the effect of human risk. HRA consists of various techniques to model the unintended human behaviour of individuals, also known as human error.

The various models available to approach human error are divided into two categories: first and second generation. According to Baziuk the features of the first generation models are the below : ''*(1) binary representation of human actions (failure/success), (2) attention on human actions' phenomenology (human error taxonomy), (3) low attention in cognitive actions (lack of a cognitive model), (4) emphasis on quantifying errors, (5) dichotomy of errors (omission and commission), (6) indirect treatment of context*'' (Baziuk et al, 2015). According to De Galizia, the First-generation methods emphasise on the skill and rule base level of human actions and do not consider such things as the impact of context, organizational factors and errors of commission. However they are considered to be useful and many are in regular use for quantitative risk assessments (De Galizia et al, 2015)

As described in subchapter 1.1, the most dominant approaches to conceptualise human error are: Ergonomic/ Contextual approach, Behavioural approach, Cognitive approach and Sociotechnical approach as well as the 2nd Generation models.

One of the first-generation tools that belongs to Ergonomic / Contextual approach, is Human Error Assessment and Reduction Technique (HEART) (Williams 1986) which is about evaluating the probability of a human error occurring throughout the completion of a specific task. HEART is a cross sector tool that is applicable to any domain where human reliability is important, and it has been successfully applied in many industries for quantifying the risk of human error.

Another example of Ergonomic/ contextual approach is SLIM model (Success Likelihood Index Methodology). According to Embrey, ''*SLIM provides a set of models for the factors that influence human error for commonly occurring activities such as alarm response, actions, checking, information retrieval and communication*'' (Embrey et al, 2012). Basically, SLIM underlies that the likelihood of an error in a particular situation depends on the combined effects of a pretty small set of performance shaping factors (PSFs) such as environment, morale and motivation of an operator, competence, time constraints, etc.

A first-generation tool belonging to the Behavioural approach, is Technique for Human Error Rate Prediction (THERP) (Swain and Guttmann 1983) which involves performing a task analysis to provide a description of performance characteristics of human tasks being analysed. It describes both how events are to be designed as well as how they are to be quantified. Moreover, Time-Reliability Correlation model (TRC) is another behavioural approach which is about the trade-off between speed and accuracy or time

and reliability. The main assumption of TRC is that the principal factor in determining the probability of a failure, is the time available for the diagnosis of a system fault. (Modares,1993)

According to Baziuk Modern or second generation (models that are more appropriate to explain human behaviour, are characterized by*: ''(1) consideration of cognitive and organizational factors, (2) refer to cognitive model and/or group / organization model, (3) need to be carried out by a team of experts including experienced operators, design and control engineers, cognitive or work psychologists''.* These models instead of focusing in error frequencies, are focusing on error causes, emphasising on qualitative aspects, interaction and factors' interdependences (Baziuk et al, 2015). Many researches like De Galizia agree that second generation methods are ''generally considered to be still under improvement'' but however the case, these methods can provide useful insights for human reliability issues (De Galizia et al, 2015).

Furthermore, some second-generation models are ATHEANA and CREAM which developed a more holistic and structured examination of human error. ATHEANA - A Technique for Human Error Analysis (Cooper et al, 1996) identifies all the interactions affecting the weighting of the factors of their influence on a situation.

Cognitive Reliability and Error Analysis Method abbreviated as CREAM - (Hollnagel, 1998) is based on three primary areas of work; task analysis, opportunities for reducing errors and possibility to consider human performance.

Financial Incident Analysis System (FINANS) formed by Meghan P. Leaver (Leaver et al, 2016) is the first system developed to achieve three principle goals: 1. provide a standardized method for collecting data on operational incidents occurring on the trading floor, 2. develop a reliable method for analysing and extracting human factors related to operational incidents, 3. to provide practical insight into how these contributors might be improved.

FINANS contains two parts. The first part is collecting voluntary operational trading incident reports. The trading incidents are the activities which result in an avoidable financial loss, for example, due to poor decision making or a compliance breach from employees working on financial trading floors. The second part is a taxonomical system that analyses and interprets incidents in order to identify the human factors issues reported within them. Overall it is a tool that examines the role and extent of human factors–related problems underlying operational incidents in financial trading.

Cognitive approach includes models like SRK, HCR, GEMS, HERMES, TALENT, SHARP and Information processing. Human Cognitive Reliability (HCR) model is based on Rasmussen's human behaviour model and General Physics. The two hypotheses for this model are : all the behaviour types of human actions can be classified into skill-based, rule-based, and knowledge-based according to the Rasmussen's human behavior model; the probability of every behavior error is only related to the proportion of permitted

time to available execution time T (Qiu et al, 2015). Systematic Human Action Reliability Procedure (SHARP) main objective is to help the analysts in determining interactions that are important to the risk. This framework assumes that the responsibility for incorporating human interactions into the PSA logic structure is shared between the system analysts and the human reliability analysts (Kosmowoski,1995).

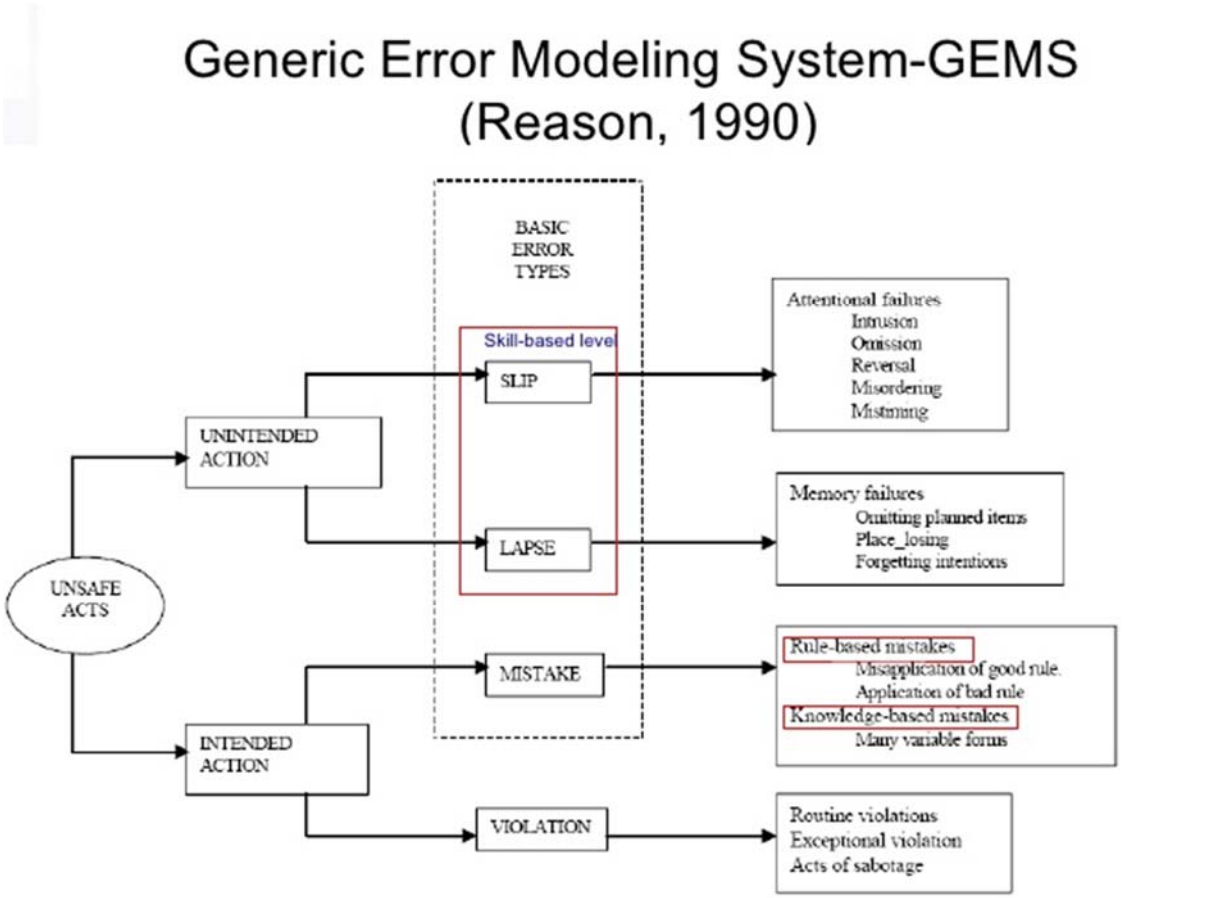
Furthermore, the generic error modelling system (GEMS) was proposed by Reason (1990) based on Rasmussen's 1982 three major categories of errors framework SRK : skill-based slips and lapses, rule-based mistakes, and knowledge-based mistakes. Moreover, it is the chosen model for this study since it is a classification scheme which facilitates the detection of the error and its correction as well as providing help for mitigation measures, ex ante, without the need for existing data from past performance.

Reason's model provides support for reasoning about possible human errors and is used to classify error types and represents the human error mechanisms. GEMS is a conceptual framework that describes in detail the potential causes for each of the Skill, Rule, Knowledge error types. It is a model that study cognitive processes of human performance and predicts human performance under certain operating conditions.

GEMS categorize errors into slips/lapses and mistakes. Slips describe the incorrect execution of a correct action sequence and mistakes refer to correct execution of an incorrect action sequence based on a wrong decision. Reason termed slips as "*execution failures*" and mistakes as "*planning failures*". The term 'mistake' can be interpreted as the result of an intentional act involving faulty conceptual knowledge, incomplete knowledge, or incorrect action specification. A malicious act is also intentional but is directed at causing harm (Liginlal et al, 2009). GEMS taxonomy of error types is a useful method to assess cognitive determinants as well as simple unintentional errors and it is a widely accepted error typology (Figure 1).

Researchers like Mason (1992) used the GEMS error typology to come up with error reduction strategies and where slips and lapses can be effectively addressed by design improvements and training.

Figure 1



(Li et al, 2011)

2.3 Human Error in financial sector

No matter how vigilant an investment management firm is, human error still might occur. Compliance expert Ralph Ebert in an essay for *finews.first*., wrote that "*Human error is the biggest weakness in the risk defence*" .Paul Hopkin, technical director at the Institute of Risk Management states that "*Ultimately, it is all about people. The management of people risk is totally and fundamentally dependent on the culture of the organisation*".

A list of Unintentional errors of Investment managers include (Cfo 2015, Leaver 2016, Kentouris 2014):

- Misleading risk – unintentional error by fund manager when issuing orders to brokers like 1) buying instead of selling; 2) buying the wrong amount of a security; and 3) buying the wrong security

- The fat finger trading error: making an entry error in a trading screen.
- Sending confidential information by mail by accident
- Misdirected faxes, accidental emails, unintentional posting or mailing of statements, or unintentional mailing of billing records to the wrong recipient.
- Hacking damages: Saving sensitive financial data on cloud applications, connecting a device containing data to a non-secure wireless network
- Saving files with corporate financial or tax data on personal device
- Accidentally deleting customized formulas
- Using figures calculated outside an enterprise program

In every process that there are human touch points involved like calculating, combining or updating performance information, there is a potential for error. Typical simple errors can happen to spreadsheets and presentations that are constantly changing. Every manual update to a spreadsheet may lead to an error. A broken link or wrong cell reference in a formula is likely to go undetected due to the false sense of security quasi-automation provides. A series of mistakes resulting from "fat fingering" a performance number, entering the wrong values into the systems or a broken link could signal broader issues with the firm and its operations (Kerr et al, 2015). We can classify these errors as slips.

Stress is common feature of modern life. According to Targoutzidis and Karakoltsidis, stress that results from the pursuit of greater levels of productivity, along with insecurity for the present situation is consider in the human error literature as a key factor for erroneous (i.e. unintentional risky) behaviour (Targoutzidis et. Al. 2009: 879). HSE defines stress as ''*the adverse reaction people have to excessive pressures or other types of demand placed on them''*. Work related stress cause severe physical and psychological conditions to any worker. Depression and anxiety affect the mental well-being of staff but also organisational performance through increased staff turnover, poor work performance and accidents at work.

Boredom, monotony and repetitiveness can be some examples of the conditions under which skill base errors can occur. Since skill base behavior is a routine behavior and mainly automatic and as Baker mentions ''*a skill that goes beyond intelligence becomes plainly mechanical"* (Baker 1992: 494). According to Loukidou et al, when mastering a task to a level of expert performance, where it no longer demands conscious effort may lead to boredom and experts that tend to feel more bored are presenting more lapses of attention, need more time to correct errors and have more accidents (Loukidou et al, 2009). They also assume that when performing a task that is boring, uninteresting and repetitive, attention will deteriorate and this will be expressed as lower performance which includes errors.

When Time pressure is experienced by individuals, it brings them to a stressful condition, which can lead to poor performance. As Saptari pointed out, ‘’*when human workers are required to complete the assigned task as soon as possible, this condition can induce mental workload and stress on the workers and subsequently lead to the occurrence of human error*’’ (Saptari et al, 2015).

As an effort to maximise productivity and profitability, many organizations have adopted longer working hours with complex and abnormal shifts. Researchers like Townley found that a range of stress-related symptoms, including excessive fatigue and headaches, were predominately associated with the need to manage excessive workloads and simultaneously meet unrealistic targets and deadlines (Townley,2000).

Moreover, extreme and continuous exposure to stress would reduce an individual capacity to perform at work, Work stress is a major issue in the occupational safety and health aspect as well as organizational wellbeing as it risks the employees’ health and organizational success (Mohd et al, 2011).

While human errors can be reduced with the help of checklists, peer reviews, vigilant compliance oversight and standardizing materials it is impossible to eliminate them. For that reason, investment managers are vulnerable to operational, regulatory and reputational risks (Kerr et al, 2015).

2.4 Risk Perception

Mistakes are also errors occurring from error in judgement or decision-making (“intended actions are wrong”) - where people do the wrong act albeit with good intentions due to their own inaccurate personal perception of a situation. Intentional actions like mistakes and violations are performed consciously but the desired result is not achieved since the plan chosen by someone is not suitable for achieving the desired goal.

Based on the literature of risk perception, Intentional risk-taking behaviour is examined. According to Gonzalez, risk perception influences people behaviour even in its absence – by seemingly “proving” that careless behaviour is appropriate and also is highly volatile and has noticeable influence on behaviour (Gonzalez et al,2003).

Risk perception is a subjective and personal judgement that people make about the characteristics and severity of some negative occurrences and show which of these risks people care about and how they deal with them. According to Brown, risk perception is a very personal process of decision making based on an individual’s frame of reference which was developed over a lifetime, along with many other factors (Browns, 2014).

For every individual person, the risk is a distinct attribute since what is perceived by someone as a huge risk may be regarded by someone else as a far much lesser risk. Risk perception is about the way people see and feel toward a potential danger.

Many authors agree in their research work that risk is conceptualized as a subjective construct influenced by how an event is interpreted (Weber, 2004; Rottenstreich& Tversky, 1997; Tversky & Koehler, 1994). As Weber (2004) notices "*First, perceived risk appears to be subjective and, in its subjectivity, casual. That is, people's behaviour is mediated by their perceptions of risk. Second, risk perception, like all other perception, is relative*" (Weber 2004:172). Ajzen and Fishbein (1980) believe that behavioural intentions are cognitive in nature, and act as a representation of a person's readiness to engage in a specific behaviour.

One of the first studies on risk perception performed in the mid-70s was the one of Paul Slovic, Baruch Fischhoff and Sarah Lichtenstein who found that people either denied the impact of uncertainty, or misjudged the nature of risks, or had unjustified confidence in perceived facts and in general were wrong too often when they were certain that they are right (Fischhoff et al 1978:561). Furthermore, Wason and Johnson Laird have shown that people have considerable confidence in their own erroneous syllogistic reasoning (Wason et al, 1972).

Tversky and Kahneman (1986) found that risk perception is influenced by the way the decision-making problem is framed and information is communicated (e.g. whether the effects of an event are expressed as positively or negatively).

Gonzalez also noticed that ''*people in the face of very likely events either overestimate the probability of their occurrence or neglect it at all*''. Thus, there is a dangerous bias in how people perceive and interpret risky situations, where probabilities of disastrous events are usually very low (Gonzalez et al, 2003).

It is clear that risk perception leads to intentional errors. Another important feature of intentional errors is violations. These are intentional and usually well-meaning failures, such as taking a short-cut or non-compliance with procedures e.g. deliberate deviations from the rules or procedures. They can also be wilful, for instance fraud, as a result from an innate impulsion to complete the set task regardless of the consequences.

According to Massaiu, an individual can neglect and misinterpret the prescribed task for various reasons *''because of a lack of knowledge, because the goals are poorly defined, because the system contains conflicting goals and principles, because the conditions of executions do not make possible to perform the task in all situations, etc''* (Massaui 2005: 7).

In every complex and dynamic environment, individuals in order to avoid errors are required to maintain high level of awareness and understanding of situation in addition to knowledge and skills. A lack of situation awareness has been cited as one of the main

causes of slips and has been defined as ‘‘*the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future*’’ (Liginlal et al, 2009).

2.5 Risk Perception models

As discussed in subchapter 1.1, risk perception models can also be classified in certain approaches: Behavioral approach. Cognitive approach. And Socio-cultural approach.

Risk Homeostasis Theory (RHT) is a Behavioral approach, proposed by 1982. The model supports that individuals try to maintain an equilibrium of perceived risk that optimises the balance of benefits and potential losses of the risky choice. Every individual has an acceptable amount of risk that finds tolerable and is willing to take. If the perceived level of risk in a person's life part changes, they will compensate by reducing or increasing the amount & severity of risks they take. Risk homeostasis theory has been found effective in many areas. (Wilde, 1982). The important aspect of RHT is that the analysis happens in an absolutely individual level. Thus, when a situation is perceived as being risky to some degree, the decision-maker can decide whether the risk is acceptable or not and from that decision adjust his behaviour.

In the literature of risk perception, many academic authors examine the intentional risk-taking behaviour based on the psychometric approach (Targoutzidis 2009, Diacon 2004, Davies and Brooks 2003), which is a Cognitive approach. The psychometric paradigm adopted by Fischhoff et al. (1978), and is dedicated to systematically measure psychological properties, usually via tests. According to the psychometric approach, the behaviour of an individual against risk is determined by what is perceived to be the case rather than by what is the case. Moreover, this perception is defined mainly by various personal feelings which are examined through psychometric tests. (Targoutzidis 2009) In other words the psychometric approach is based on direct measurement of creativity and/or its perceived correlates such as knowledge, abilities, attitudes, and personality traits in individual which are then studied through tests.

Furthermore, the mental models belong in the field of Cognitive approach. The ‘’mental models’’ approach to risk communication uses a form of deductive reasoning, one of the multiple types of reasoning which is connected with decision making. According to Gibson ‘’*The approach assumes that, in order to make a decision about an issue, an individual will construct an artificial (mental) reality in order to test a series of simulated scenarios using data previously collected and valued by that individual*’’ (Gibson et al, 2016). Finally, the decision about what action to take lies upon a logical interpretation of the results of these tests, and the simplest the tests the easier the decisions will be made.

A second Cognitive approach to examine intentional risk taking is Decision-making under uncertainty. Value expectancy models like Theory of Reasoned Action (TRA), choose how they will act in accordance to a balance of (perceived) potential gains and losses. According to Fishbein, within TRA, behavioural intention ''is an additive function of two variables: attitudes (positive or negative evaluation of performing a behaviour), and subjective norms (perceived influences that others may have)'' (Fishbein, 2008).

Prospect theory is another Cognitive approach developed by Kahneman and Tversky in 1981 where their work became fundamental to the evolving discipline of behavioral economics. According to this framework people respond differently to information about the consequences of a behavioural decision depending on whether the same consequences are presented as gains or losses. Also, outcomes are expressed as positive or negative deviations (gains or losses) from a reference outcome (Tversky et al,1981). In simple words, Prospect theory predicts that individuals tend to be risk averse in a sphere of gains (or when things are going well) and risk seeking in a sphere of losses.

Another approach to examine the intentional risk-taking behaviour, is the Socio-technical theory. In this case risk management considers the interaction of both technical aspects as given by the standards, guidelines, processes and the human aspect of project management. Leavitt's socio-technical model consist of four components: Structure, Task, Actor and Technology where these variables are high interdepended and a change in one variable will result in changes in the others as well (Leavitt, 1964). In order to apply the model, an organisation firstly needs to define exactly what each component does within the organisation and then to analyse how the change will affect these processes. In other words, before changing any one of the four components, you should evaluate the impact on the other three components. For a successful change implementation, you need to find the right balance between all of components.

2.6 Risk perception in financial sector

Professor Paul Slovic was the founder of Decision Research, an organization established on 1976 dedicated to helping individuals and organizations understand and cope with the complex and risky decisions. At the Decision Research organization during their innovative studies on risky behaviours and hazardous activities, Slovic and his colleagues were first started risk perception research in behavioural finance, accounting, and economics.

Since the 1990's, the Decision Research academics (for example Olsen 1997, Slovic 2001, Gonzalez& Svenson 2014) began to apply an array of behavioural risk characteristics (cognitive and emotional issues), various findings, and research

approaches from the social sciences to risk perception studies within the investment decision making and financial sphere. Moreover, Olsen (1997) argued that the perception of financial risk, held by both experts/ professional investors and laypeople, is multidimensional and extends beyond the variables of size and probability.

Interested academics who are not privy to the work of the Decision Research group have also spread further this risk perception work throughout some fields for instance those of financial psychology, behavioral accounting, economic psychology, and consumer behaviour. (for example, Diacon 2004; Parikakis, Merikas, and Syriopoulos 2006; Ricciardi 2004; Shefrin 2001).

Sindhu & Kumar explain the term 'perception' as the process by which an individual investor is in search of notable clarification of sensory information so that he/she can make a final judgment based on their previous working experience and present skill level. The 'risk perception' concept represents the way in which investors view the risk of financial assets, according to their concerns and experience (Sindhu et al 2014 :16).

Heywood mentions that portfolio managers are viewing the chance of not meeting the targets set out in the investment management agreement as a risk and it is possible that they will have a different perception of the risk of not meeting those targets as being different to exceeding them. Moreover, the nature of the risks perceived by an individual investment manager are likely to differ from time to time, and at any point in time different fund managers will have a different perception of the risks within the market (Heywood et al, 2003: 1071)

In recent years investment professionals can get overwhelmed by the amount of available information and the numerous investment choices, accessible by the advanced information technology and the Internet. These new forms of Internet communication include bulletin boards, online search engines, chat rooms, web sites, blogs, and online trading. According to Ricciardi, a direct link exists between the cognitive biases and heuristics (rules of thumb) espoused by behavioural finance and the problems associated with information overload, for the investors (Ricciardi V., 2008)

One source of intentional human error risk is the behaviour of employees who do not follow internal policies. An example is downloading unauthorised applications for personal or business use that might cause dangers of malicious viruses and unlicensed software getting into company systems. Apathy, ignorance, negligence, lack of awareness, mischievousness and resistance to information security organisational policies, are the roots of information security incidents in many cases (Safa et al 2012:15).

Moreover, poor communication is seen as undermining performance, with poor or unclear communication procedures creating uncertainty on how information is interpreted, and team conflict on its management. As Leaver notes ''*lack of leader vigilance and monitoring (e.g. a lack of leader inclusiveness) leads to increased likelihood*

of deviation from standards and procedures and subsequently elevated instances of error…leadership style in finance is seen as "complacent, inward looking, indecisive and paranoid" resulting from a lack of leader inclusivity (autocratic style executive management) and crucially, this leads to the incubation of error in the organisation'' (Leaver,2016).

A list of Intentional errors of Investment managers includes (Leaver 2016, Massaiu 2015 imolin.org, Palmay et al 2008):

- Fraud: dishonest behaviour/ misappropriation of customer asset by the management firm or employees, forgery, theft
- Money laundering profiting from commission-driven brokerage or securities firms willing to invest huge sums on the behalf of money launders, or even controlled by criminal elements specifically for that purpose.
- Breach of regulatory and other mandatory guidelines: Breach of clients' guidelines e.g. managers purchase securities not permitted under the contract between client and manager or under law and regulations
- Mispricing e.g. incorrect valuation of client's funds
- Shaping incorrectly the needs of the customer into the portfolio

However, deliberate acts of fraud or money laundering are considered to be violations. Violations are intentional failures where deliberately someone is doing the wrong thing. According to Manchi, deliberate violations differ from errors since they are mostly associated with motivational problems like low morale, poor supervisory examples, perceived lack of concern, the failure to reward compliance and sanction non-compliance, etc (Manchi et al, 2013).

Chapter 3

Methodology

3.1 Introduction

Rasmussen (1982) developed the skill-rule-knowledge framework to create a practicable taxonomy of human errors. The framework identified three performance levels Skill based, Rule based and Knowledge based levels (Rasmussen, 1982). Reason (1990) used these three performance levels (SB, RB and KB) to develop a conceptual framework called the Generic Error Modelling System (GEMS)in order to locate the origins of basic human error types (Reason, 1990).

As discussed at the previous chapter, James Reason's Generic Error Modelling System (GEMS) will be used for this study and it draws on cognitive psychology. The aim of GEMS is to describe how switching occurs between the different types of information processing (skill, rule, knowledge) in tasks. Gems integrates the different error mechanisms (slips, lapses and mistakes) and the three levels of performance (SRK-Skill, Rule, Knowledge). It is a simple way to capture most indicators of human error and also facilitates the search for methods of error correction.

According to GEMS, errors can occur at each level of performance. At the time that the error is occurred at the skill-based level, individual's behaviour is engaged in problem solving. Differently, the rule-based and knowledge-based levels of performance are only activated after the individual has become aware of a problem.

Skill-based slips and lapses are usually errors resulting of inattention or misplaced attention. Skill base performance is routine behaviour based on learned skills for which the cognitive commitment is very low and reasoning is unconscious/ automatic, where the environment is familiar and there is no decision making or problem solving (Reason,1990). Reason considers that essential condition for a slip is the existence of attentional capture, associated with distraction or preoccupation.

Ruled based behaviour is when the person recognizes the situation and applies the right procedure to perform the task, and then performs a series of actions by the use of procedures. There is cognitive engagement since the person follows remembered or written rules. Rule-based mistakes are usually resulting from picking an inappropriate

rule caused by misconstrued view of state, over-zealous pattern matching, frequency gambling, deficient rules.

Knowledge based mistakes usually result due to incomplete/inaccurate understanding of system, confirmation bias, overconfidence, cognitive strain (Reason,1990). Knowledge based performance is about improvisation in unfamiliar environments, no procedures or rules available for handling situation, reacting based on the information available and the knowledge gained in completely conscious manner.

Reason's skill-rule-knowledge taxonomy categorizes the basic differences that appear in human errors. As Trepess notes '' *At some level it can be applied to most studies of human error but in some cases it can only be applied in part because a taxonomy is often specific to the domain and purpose of the human error analysis*''(Trepess,2003)

The accuracy of error prediction depends mostly on the understanding of the factors giving rise to the errors. As Korsten notices ''*This understanding requires a theory, which relates to the three major elements in the production of an error: (a) the nature of the task and its environmental circumstances, (b) the mechanisms governing performance, and (c) the general nature of the individual An adequate theory should therefore include the ability to forecast both the conditions under which error will occur as well as the particular form that it will take*'' (Korsten et al, 2004).

Figure 2 table by Dr John Rooksby, shows clearly the characteristics of the three error types -skill/ rule/ knowledge - and under what general circumstances are occurring.

Figure 2:

GEMS: CHARACTERISTICS OF ERROR TYPES

	Skills Based Errors	Rule Based Errors	Knowledge Based Errors
Main Error type	Slips & lapses	RB mistakes	KB mistakes
Activity type	Routine actions	Problems solving activities	
Attention	Often elsewhere	Directed at problem related issues	
Control mode	Mainly automatic	More conscious	
Predictability	Largely predictable	variable	
Frequency	Common	Uncommon	
Opportunity	Very high	Very low	
Detection	Usually easy	Difficult and often through intervention	

For every level of performance, GEMS has a list of potential types of error, as well as the conditions under which this error is more likely to occur. Thus, by defining the level of performance and the conditions, an analyst can identify the type of error that might occur. This type of error has then to be translated in terms of the specific errors linked to the specific features of the task examined.

More precisely, Reason's list of the various error mechanisms and which level of cognitive control they are associated with as well as the related conditions for each level of performance are clearly shaped at Figure 3 by Antonis Targoutzidis (Targoutzidis 2009 :153).

Figure 3: Error Modes

TYPE	DESCRIPTION	CONDITIONS
Skill-based performance		
Inattention (omitted checks):		
Double-capture slips	In two similar actions of parallel sequences, jumping to the action with the strongest schema	a) Well practiced activity in familiar surroundings b) Intention to depart from custom c) Departure point beyond which 'strengths' of the associated action schemata markedly different
Omissions following interruptions ('program counter failures')	Omission of one or two steps of a sequence (usually secondary corrective routines) after interruption	a) external event b) rule based intervention and return to skill-based performance
Reduced intentionality	Intention for an action overlaid by other demands ("what-am-I-doing-here" or "I-should-be-doing-something")	Delay between formulation of intention and execution
Perceptual confusions	Accepting look-alikes, or wrong things in the proper location.	a) oft-repeated routine tasks b) unusual or unexpected stimuli
Interference errors	Blends or transposition of speech and actions	two simultaneously active plans or actions competing for attention
Overattention (mistimed checks):		
Omissions	Unplanned check leads to the impression of being further along thus omitting steps.	Absence from the task or interruption leading to an unplanned check of the progress.
Repetitions	Unplanned check leads to the impression of being in earlier steps thus repeating steps.	
Reversals	Unplanned check leads to bi-directional consequences (omissions or repetitions).	
Rule-based performance		
Misapplication of good rules:		

First exceptions		A confounding "strong-but-now-wrong" practical rule leads to wrong assessment	a) A practical general rule proven unexceptionally strong in the past b) A non-obvious first exception to the rule
Signs, countersigns and nonsigns		Failure to see that a general rule is inapplicable in the certain case – rejection of countersigns	a) Signs (input satisfying rule), countersigns (input disputing the rule) and/or nonsigns (noise) b) Complex, dynamic, problem-solving task
Informational overload		Not processing all information, and selecting only matching components	Local state indications exceeding cognitive capacity of the individual
Rule strength		Selection of a 'strong' rule without checking if it totally matches in the situation	A 'strong' (successfully applied in many cases in the past) rule partially matching the situation
General rules		Preference to higher level rules (they are usually 'stronger')	A higher level rule partially matching the situation
Redundancy		Attention to only a few (salient) elements or features assuming internal rules that may not apply any more	a) Previous experience of the operator. b) many elements and features related
Rigidity		"to a person with only a hammer everything looks like a nail"	Previously successfully applied ('strong') rule
Application of bad rules:			
Encoding deficiencies	Properties not encoded	Not taking account of a parameter at all	a) Many parameters b) Limited experience
	Properties inaccurately encoded	Inadequate perception of parameters (intuitive physics)	Existence of parameters that are inadequately perceived by human mind
	Dominant exceptions	Taking the exception for the rule	Repetition of exceptions (e.g. due to domain-specific characteristics)
Action deficiencies	Wrong rules	Adopting a wrong rule and following it strictly	A wrong rule whose vast majority of aspects are coincidently right
	Inelegant rules	Following a non-optimum rule	a) Many routes to solution b) Forgiving environment c) Absence of expert instruction
	Inadvisable rules	Following effective (risky) rules but not advisable in the long run	a) Possible rules with low failure probability but higher effectiveness b) Experience
Knowledge-based performance			
Selectivity		Selective processing of task information (psychologically salient rather than logically important)	Cognitive overloading
Workspace limitations		FIFO information processing	
Out of sight out of mind		Omission of information that is not present (availability heuristic)	
Confirmation bias		Insisting on a wrong hypothesis due to reliance on previous data	

Overconfidence		Insisting on a wrong hypothesis due to self-overconfidence	a) very elaborate plan b) plan is a result of effort and has reduced anxiety c) plan is a team (especially small) product d) plan has hidden objectives
Biased reviewing ('check-off' illusion)		Not all factors taken into account altogether and all of the time.	Many affecting factors
Illusory correlation		Missed or mistaken covariation (due to human mind limitations in it)	a) existence of potentially covariating factors b) theories for or against the potential covariation
Halo effects		Merging orderings due to biased preference to single orderings.	Existence of simultaneous separate orderings.
Problems with causality		Reducing contingencies due to oversimplified causality	a) representativeness heuristic (perceived similarity between cause and effect) b) availability heuristic (salience) c) hindsight bias (knowledge of outcome increases likelihood) d) 'illusion of control' (self power overestimation)
Problems with complexity	Problems with delayed feed-back	Laging behind events and avoiding delegation (to compensate)	Delayed feedback (even a little) Stress (mainly for non delegating)
	Insufficient consideration of processes in time	Focusing on the current situation (as static) and not on forecoming ups and downs	
	Difficulties with exponential developments	Underestimating rate of change due to intuitive inefficiency with exponential processes	
	Thinking in causal series not causal nets	Focusing on a narrow causal chain to the goal without seeing side effects.	
	Thematic vagabonding	Flitting from issue to issue especially when facing difficulties	a) Poor performers b) Poor self assessment c) Desire to escape
	Encysting	Insisting on insignificant issues disregarding more important	a) Poor performers b) Poor self assessment c) Desire to escape

3.2 Data collection instruments

A pilot study was conducted on the portfolio management field and therefore only limited information on the sources and magnitude of variation of response measures can be provided.

The study used interview schedules and the questionnaires were used because they are able to gather sufficient amounts of data from very inexpensively.

The interviews were held with 2 key personnel of the sector, individually. The one is working for a private investment company while the other one works for a private bank and both interviews were held in person. Each participant was visited twice and was given a set of questions that had to answer.

The investigator was mainly interested in attitudes, feelings, perceptions, and views based on leadership strategies. The study used a qualitative approach since it is more appropriate to achieve an understanding of the causal chain of events that contribute to human error.

The investigator firstly studied about the field of Portfolio Management and set the first meeting with the interviewers. After discussing in depth with both of them, the investigator collected information about the nature of portfolio management sector as well as its process, the steps of the process and tasks of each step. The findings are described at section 4.1 Portfolio Management Process.

The Portfolio Management has three steps: Planning, Execution and Feedback, where each test has many tasks a manager has to follow. After the investigator gathered all the information, she decided to choose two of the three steps of portfolio management process to deal with: Planning step and Execution step.

Each of these two steps has plenty of tasks where possible human errors may occur. The investigator chose the performance level of each of the selected tasks (skill/rule/knowledge) based on Reason's Error Mode table (figure 3) and then examined the conditions of each of the tasks. Based on these conditions the investigator shaped some of the errors that are possible to arise.

The investigator then prepared a set of questions to present to the interviewers on their second interview, which can be found at Appendix A. A table was also formulated with 12 of the task's errors and the conditions under they might occur (Table 1, Appendix A). The table was also presented to the interviewers as part of the interview. Then they were asked to use Table 2 (Appendix A) to assess the likelihood of every error as well as

the impact these errors have. The description of the probability impact matrix and the scale used is presented at the following section 3.3 Data Analysis and Presentation.

3.3 Data Analysis and Presentation

The study yielded qualitative data as the investigator used interviews which were then analysed. A qualitative risk assessment was used, since the determination of both consequence and likelihood of occurrence is largely based on the judgement and experience of qualified and competent personnel.

Probability impact matrix is one of the commonly used qualitative methods for risk assessment. It allows to merge both probability and impact onto the same scale. Since it examines each factor associated with a risk (error) and their possibility of occurrence, it prioritizes risks and helps the companies to design a strategy that will be suitable in tackling them and that was the main reason for choosing this too for the Thesis.

Table 2 (of Appendix A) was given to the interviewers along with Table 1 (of Appendix A) and the investigator explained to them how to use it. Each of the 12 errors (risks) of Table 1 was given two sets of criteria which are then viewed on the probability and impact matrix. Each error should be rated based on the likelihood that it will occur and separately rated regarding how much of a problem would be created if it were to occur.

After the portfolio managers awarded the total (scores) for likelihood and severity of the risks (the errors), we proceed by multiplying the two variables. The result defines the degree of risk.

Probability is the likelihood of occurrence of errors indicated in this study. This is expressed in an ordered scale and description as follows:

1-Prossibly: Probably could happened
2- Likely: Heard of in the industry
3-Occasional: Has happened to me
4- Frequent: Occurs regularly

Severity is the gravity of harm/impact in the event of occurrence in this study, described and expressed in scale as follows:

1- Insignificant: Small or no effect on the project
2- Moderate: Unlikely to cause damage or threaten the survival of the project
3- Critical: Likely to cause some damaging effect on the project
4- Catastrophic: Threatening for the survival of the project

Since Risk Rating result from the multiplication of Likelihood and Severity, the description and the scale defining Risk in this study is as follows:

1-3: Low Risk

4-6: Medium Risk

7-9: High Risk

10-16: Very High Risk

Figure 4 shows exactly the Risk Matrix used.

Figure 4

		Likelihood			
		1- Possibly: Probably could happened	2- Likely: Heard of in the industry	3 - Occasionally: Has happened to me	4 - Frequently: Occurs regularly
Severity	1 - Insignificant: Small or no effect on the project				
	2 - Moderate: Unlikely to cause damage or threaten the survival of the project				
	3 - Critical: Likely to cause some damaging effect on the project				
	4 - Catastrophic: Threatening for the survival of the project				

Risk Rating: Likelihood x Severity	1-3 Low Risk	4-6 Medium Risk	7-9 High Risk	10-16 Very High Risk

3.4 Ethical Considerations

Ethical issues such as confidentiality, responsibility, informed consent, honesty and openness in dealing with other researchers and research subjects, physical and psychological protection, and explanations of the objectives of the investigation and 'de-briefing' subjects afterward should, therefore, be considered. The rights of informants or participants in this study were protected by all means.

The principle of voluntary participation was encouraged and participants were not coerced into participating in the study. Those participating in the study were not put in a situation that would prove dangerous to them as a result of participating. The researcher guaranteed informants' confidentiality. The anonymity of the participants was maintained by asking them not to disclose their names in any of the research instruments. A sample interview and a description of the questions is provided forthwith;

Chapter 4

Results

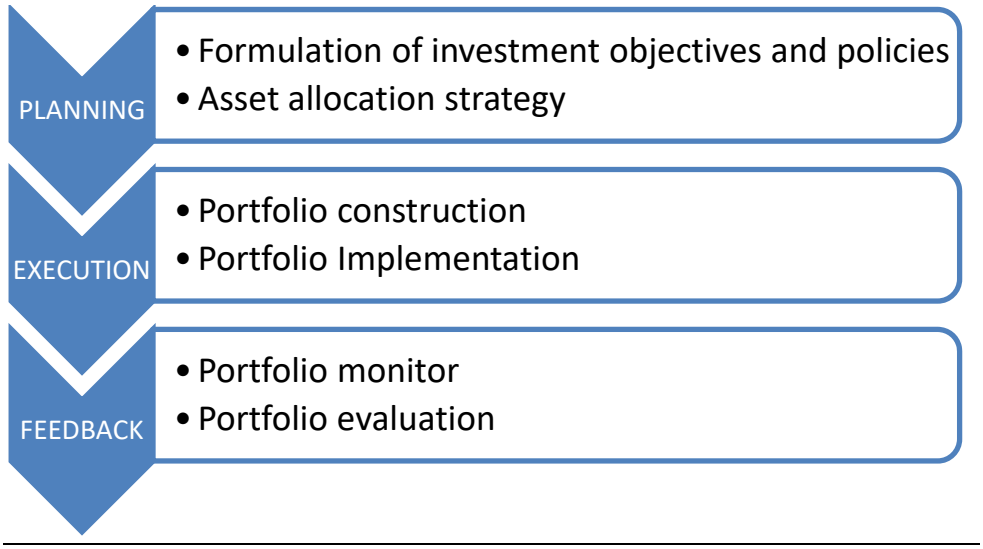
4.1 Portfolio Management Process

Portfolio managers buy and sell shares, bonds and other assets for their customers aiming to raise the amount of money they hold. This requires a lot of expertise in order to understand their customers' needs, to research companies and assets to invest in, read what markets are doing and understand how values will change in relation to world event (ICAEW, 2018).

A successful Portfolio manager is the one who selects the right investment tools in the right proportion to generate optimum returns with a balance of risk from the investment made. In order to accomplish this, one must follow a process which includes some basic tasks like understanding the client's investment objectives and availability of funds, matching investment to these objectives, recommending an investment policy, balancing risk and studying the portfolio performance from time to time, taking a decision on the investment strategy based on discussion with the client, changing asset allocation from time to time-based on portfolio performance (Olssen,2005).

The process a portfolio manager follows consists of 3 steps: planning execution and feedback. (Figure 5)

Figure 5: The 3 steps of Portfolio Management Process



The planning step: The first thing a portfolio manager does is to discuss with the client in order to understand his investment objective, goal and level of risk the customer is willing to take. Thus, after the agreement with the customer the investment objectives and policies are formulated, constraints are determined, capital market expectations are formed, and strategic asset allocations are established and an investment policy statement is created (Maginn et al,2018). An investment policy statement is a formal document between the portfolio manager and the client which clearly sets the investor's goals, objectives and constraints. It allows the investor to determine the factors that are personally important and should be reflected in the investment plan and without it the success of a financial plan is at risk (Reilly et al. 2002 :53). The failure to follow an investment policy statement is evidence of a breach of fiduciary responsibility.

Tasks derived from the interviews:

I. Set meeting with the client to discuss his values, beliefs, priorities, objectives (desired investment outcomes) and constraints (client's specific liquidity needs, time horizon, unique circumstances, any tax issues and legal and regulatory requirements. Understanding how much risk an investor is willing and able to assume, and how much volatility the investor can endure.
II. Formulation of the Investment Policy Statement which includes : brief client description, the duties and investment responsibilities of the parties involved (client, any investment committee, the investment manager, and the bank custodian), the statement of the unique investment goals, objectives and constraints, the schedule for reviewing the investment performance and the IPS , performance measures and benchmarks to be used in performance evaluation, any other considerations to be taken into account in developing the strategic asset allocation, investment strategies and style, guidelines for rebalancing the portfolio based on feedback.
III. Forming of capital market expectations. Forecasting the risk and return of various asset classes over a long term in order to select portfolios that either maximizes the expected return for certain levels of risk or minimize the portfolio risk for certain levels of expected return.
IV. Determination of the strategic asset allocation which is achieved by combining the IPS and capital market expectations in order to determine target asset class weights. The portfolio manager selects from various asset classes and investment options and allocates assets in a way that achieves optimum diversification while targeting the expected returns for the client. If there are any changes in the circumstances of the investor or the market expectations then portfolio manager needs to change the portfolio strategy and to tactical asset allocation. In case that changes

become permanent, the investment policy statement must be updated to reflect these changes and the temporary tactical allocation may become the new strategic portfolio allocation.

The execution step: After the planning step comes the construction and implementation of the portfolio. The manager together with the investor determine how to allocate the available funds across their options (bonds, stocks, securities etc). The portfolio selection/ composition should minimise the investor's risk as well as meeting the investor's needs according to the policy statement. The next step in the process is to implement this portfolio. What is important to be noted in this step is that high transaction explicit and implicit costs like taxes, fees, commissions, bid-ask spread, opportunity costs, market price impacts, etc. can reduce the performance of the portfolio. Hence, the execution of the portfolio needs to be appropriately timed and well-managed (Olsson, 2005).

Tasks derived from the interviews:

I. Selection of the specific assets for the portfolio composition based on analysts' inputs
II. Use of portfolio optimization techniques like portfolio optimization—quantitative tools for combining assets efficiently to achieve a set of return and risk objectives
III. After the decision about which option will be bought or sell, the portfolio manager transmits the order internally to the trading desk
IV. The trader arranges for execution of the order with a broker-dealer

The feedback step: after the funds are invested according to the plan, the manager monitors, evaluates and update the portfolio compared with the plan. The managers must continually monitor the investor's needs and the capital market conditions so that they can evaluate the portfolio's performance and compare the relative results to the expectations and requirements of the policy statement. Any changes, updating and rebalancing suggested by the feedback must be examined carefully to ensure that they represent long-run considerations.

Tasks derived from the interviews:

I. Monitoring the investments
II. Stay informed of changes in clients' circumstances
III. Systematically review the risk attributes of assets as well as economic and capital market factors
IV. Rebalance the portfolio (considering taxes and transaction costs)

V. Measuring the portfolio's performance relative to the benchmarks and rates of return
VI. Performance attribution to examine f those rates of return to determine the factors that explain how the return was achieved and why the portfolio performed as it did
VII. Performance appraisal evaluation of how well the portfolio manager performed on a risk-adjusted basis relative to a benchmark.

4.2 Tasks - conditions and errors

Based on Reason's list of potential forms of errors and the related conditions for each level of performance (figure 3) a list of possible human errors on some of the many tasks of the Planning and Execution steps is formulated. The analysis is shown below.

Planning Step: Formulation of investor's personal Investment Policy Statement which clearly defines his objectives, goals and risk levels, starting with the filling of the questionnaire, creating a risk profile and finally the asset allocation strategy.

Task 1: Portfolio managers discusses (interviewing) with the potential investor and at the same time is filling a paper questionnaire about investor's risk tolerance, time horizon, priorities, objectives, constraints. These will later be imported in excel spreadsheet.

Task Type: Skill Based Performance: Filling the questionnaire it is an everyday task with no conscious control exercised by the portfolio manager, since it is a routine task.

Condition: - Inattention (omitted checks)

a) oft-repeated routine tasks: For the Portfolio Manager, filling the questionnaire is an everyday repeated automatic task which can be monotonous

b) unusual or unexpected stimuli: Usually somebody from the back office who knows the language required, translates when needed to help with a foreign customer's questionnaire. That back-office person might fail to notice an unexpected stimulus (translation) that is in one's field of vision when other attention-demanding tasks are being performed (usual tasks of back office).

Error type: Perceptual Confusion - Accepting look-alikes, or wrong things in the proper location. Due to repeated/boring actions, monotony of the automatic task, PM does not pay the proper attention.

Errors: Ticking a wrong box by mistake it means that the wrong data will be analysed on later stage and the IPS will not be correct

1. Writing the wrong contact details of the customer like email or phone leading to later issues when the customer will be missing important newsfeed and any related information about his portfolio
2. In the case of a foreigner customer (not English speaker) the portfolio manager is required to use the help of a translator who might mishear/misunderstand something thus translate it incorrect and thus the PM will fill wrongly the questionnaire

Task 2: The questionnaire data are imported to excel through a drop-down list template in order to produce the result of the risk profile of the investor and the strategy that should be followed e.g. Aggressive, Conservative, Defensive, Competitive

Task Type: Skill Based Performance: Importing data from paper to excel is an everyday task with no conscious control exercised by the portfolio manager, since it is a routine task

Condition: - Inattention (omitted checks) - a) oft-repeated routine tasks: For the Portfolio Manager, importing data to excel is an everyday repeated automatic task which needs attention and concentration. b) unusual or unexpected stimuli

Error Type: Perceptual Confusion - Accepting look-alikes, or wrong things in the proper location.

Errors: 4-Due to emotional, physical and mental fatigue choose the wrong option from the drop-down list about e.g. about the investor's income, age, risk tolerance, results to the wrong profile (and wrong strategy on later stage) thus the IPS would be totally invalid. So, with the wrong variables chosen, an investor that e.g. in reality should be Aggressive, in the IPS might appeared as Conservative and a whole inappropriate strategy would be formulated.

Task 3: Analysts develop quantitative models that illustrate the appropriate asset allocation based on risk profile (Aggressive, Conservative, Defensive, Competitive). Asset allocation strategy is based on the investor's resulting risk profile (task 2) e.g. the percentage of funds to be invested on bonds /stocks /equities /assets accordingly as to accomplish the desirable return along with the risk that the investor is willing to take. The allocation is achieved with the correct quantitative model (formulas).

Task Type: Skill Base (for errors 5 +6) Portfolio Manager's performance rolls along without his conscious attention when creating formulas or making calculation since the volume of everyday calculations can be very high.

Rule Based Performance (for error 7): Portfolio manager when developing a model is not performing a routine task so he is required to engage his brain and think.

Condition (Skill case errors 5+6): - Inattention (omitted checks)- two simultaneously active plans or actions competing for attention: Developing quantitative models is a routinised set of action for a Portfolio Manager including the creation of formulas in excel and many calculations. A formula and a calculation can be very complicated where many of their parameters can be confused.

Condition (Rule case error 7): - Application of bad rules
a) Many parameters: Portfolio manager when developing a model is strongly influenced by and confusing procedures and mindset confusing displays b) Limited experience: Portfolio manager with limited experience can misinterpret the rules he needs to follow.

Error Type (for 5+6): Interference errors - Blends or transposition of speech and actions since multiple active schemas become confused.

Error Type (for error 7): Encoding deficiencies, Properties not encoded

Errors: Due to pressure, fatigue, noise interaction (Skill) and lack of experience, knowledge, abilities (Rule), an inexperienced analyst not following procedures, might create a model which includes
5- inconsistent formulas,
6- incorrect calculations
7- use of whole numbers instead of percentages or even typos.
Thus, the wrongly generated strategy will be captured on the IPS and the portfolio manager will execute it on a later stage, risking the investor's money and his company credibility.

Execution step: Execution/ implementing of the portfolio strategy using a Bloomberg terminal/program. Through this program Portfolio manager trades, buys or sells bonds, stocks, options etc. Bloomberg terminal is a platform through which financial professionals can monitor and analyse real-time financial market data, review historical trading data and place trades .

Task 1: PM has to do 'homework' in order to choose the appropriate equities, bonds, options etc to buy or sell. That means before executing an order for e.g. buying a stock, the PM has to study the trends in a company's earnings growth, its stability, its debt-equity ratio, its price – earnings ratio etc as to achieve the best return for his customer.

Task Type: Knowledge Based Performance: Portfolio Manager has to adapt his behaviour in response to a totally unfamiliar situation since the markets are continuously change thus the figures he needs to deal with.

Condition: a) existence of potentially covariating factors b) theories for or against the potential covariation. Portfolio managers sometimes have (wrong) beliefs about the covariation among particular behaviors, traits and/or outcomes of the parameters that formulate the value of at equity/bond/ option etc. (which then they will buy or sell).

Error type: Illusory correlation - Missed or mistaken covariation (due to human mind limitations in it). The PM's beliefs are product of biased information processing rather than an accurate perception of the stimulus environment.

Error: 8- Due to wrong assumptions support patterns that do not actually exists -PM is making the wrong connection between the above-mentioned events /variables (company's earnings growth, its stability etc) thus selecting risky unprofitable stocks, bonds etc to buy or sell.

Task 2: When signing at the Bloomberg platform, the first step to start trading is to choose whether you are buying or selling. By default, the chosen option is the buy one. If somebody wants to sell, he needs to unselect buy and select sell.

Task Type: Rule Based Performance: Portfolio Manager in this case follows remembered or written rules- that is to choose accordingly the buying or selling button. PM's performance is characterized by pre-packaged actions because of the recognition of a familiar situation.

Condition: - Application of bad rules. A wrong rule whose vast majority of aspects are coincidently right. Portfolio Managers either buy or selling when trading but in some cases due to distraction they fail to properly execute an instruction and forget to change the default option when is required (to sell instead of buy). Thus, their response is unsuitable and inadvisable.

Error type: Action deficiencies, Wrong rules - Adopting a wrong rule and following it strictly

Error: 9- Due to distractions/ noisy environment - If a portfolio manager has an order to sell, he must choose the correct button by unselecting the default 'buy' button and select 'sell' button. If he forgets to select the correct button, then the whole action will be wrong causing the customer money losses.

Task 3: In order to proceed to execution of an order, the PM uses the Bloomberg terminal which also includes a keyboard with color-coded keys where each colour is for different function. In order to produce an order, the PM has to fill manually the unique customer number, the amount wishing to buy or sell, select from the list the stocks of his preference.

Task Type: Skill Based Performance: A portfolio Manager expert acts and reacts almost instinctively and creating execution orders is one of his main and important everyday activities.

Condition: - Inattention (omitted checks) a) oft-repeated routine tasks: For the Portfolio Manager, creating orders is an everyday repeated automatic task but also a very crutial task that can be stressful b) unusual or unexpected stimuli

Error type: Perceptual confusion - Accepting look-alikes, or wrong things in the proper location.

Errors: Due to time pressure and stress:

11. Stock purchased or sold in incorrect amount or price - Fat Finger error: Writing incorrect amount when entering an order, e.g. buy stocks of 1m instead of 100k or selling a stock for 1k instead of 10k

12. Wrong stock purchased or sold: Ticking/ selecting the wrong stock from the available list to buy or sell thus choosing an inappropriate stock for his strategy/portfolio

13. Writing the incorrect customer number thus proceed with the execution of an order for the wrong customer

4.3 Answers / results analysis

These 12 errors/conditions were presented to the interviewers (Appendix A) who were asked if they agree with those and also to rate error's likelihood of happening and the severity of each error as explained at section 3.3 Data Analysis and Presentation. The results of their risk rating scores (likelihood x severity) are presented below.

Risk Rating: Likelihood x Severity	1-3 Low Risk	4-6 Medium Risk	7-9 High Risk	10-16 Very High Risk

	ERRORS	ERROR TYPE	CONDITION	Interviwer 1 Risk Level	Interviwer 2 Risk Level
1	Ticking a wrong box on the questionnaire by mistake - wrong data will be analysed on later stage- IPS will not be correct	Skill base - Perceptual Confusion - Accepting look-alikes, or wrong things in the proper location	a) oft-repeated routine tasks b) unusual or unexpected stimuli - repeated/boring actions, monotony	6	8
2	Writing wrong contact details of customer like email or phone - later issues when the customer will be missing important newsfeed /related information about his portfolio	Skill base - Perceptual Confusion - Accepting look-alikes, or wrong things in the proper location	a) oft-repeated routine tasks b) unusual or unexpected stimuli - repeated/boring actions, monotony	4	4
3	Foreigner customer (not English speaker)- portfolio manager required to use help of translator who might mishear/misunderstand something thus translate it incorrect - the PM will fill wrongly the questionnaire	Skill base - Perceptual Confusion - Accepting look-alikes, or wrong things in the proper location	a) oft-repeated routine tasks b) unusual or unexpected stimuli - repeated/boring actions, monotony	2	9
4	Choose the wrong option from the drop-down list about e.g. about the investor's income, age, risk tolerance, results to the wrong profile - IPS would be totally invalid	Skill base - Perceptual Confusion - Accepting look-alikes, or wrong things in the proper location	a) oft-repeated routine tasks b) unusual or unexpected stimuli – emotional, physical and mental fatigue	9	6
5	Inexperienced analyst not following procedures creates a model including inconsistent formulas	Skill base - Interference errors - Blends or transposition of speech and actions	two simultaneously active plans or actions competing for attention - pressure, fatigue, noise interaction	8	8
6	Inexperienced analyst not following procedures creates a model including incorrect calculations	Skill base - Interference errors - Blends or transposition of speech and actions	two simultaneously active plans or actions competing for attention - pressure, fatigue, noise interaction	6	4
7	Inexperienced analyst not following procedures creates a model including use of whole numbers instead of percentages or even typos	Rule base - Encoding deficiencies, Properties not encoded	a) Many parameters b) Limited experience - lack of experience, knowledge, abilities	8	8
8	PM making the wrong connection between the above-mentioned events /variables (company's earnings growth, its stability etc) thus selecting risky unprofitable stocks, bonds etc to buy or sell.	Knowledge base - Illusory correlation - Missed or mistaken covariation	a) existence of potentially covariating factors, b) theories for or against the potential covariation - wrong assumptions support patterns that do not actually exists	4	12
9	If a portfolio manager has an order to sell, he must choose the correct button by unselecting the default 'buy' button and select 'sell' button. If he forgets to select the correct button, then the whole action will be wrong causing the customer money losses.	Rule base - Action deficiencies, Wrong rules	A wrong rule whose vast majority of aspects are coincidently right - distractions/ noisy environment	6	4
10	Stock purchased or sold in incorrect amount or price - Fat Finger error: Writing incorrect amount when entering an order	Skill base - Perceptual Confusion - Accepting look-alikes, or wrong things in the proper location	a) oft-repeated routine tasks b) unusual or unexpected stimuli - time pressure and stress	12	6
11	Wrong stock purchased or sold: Ticking/ selecting the wrong stock from the available list to buy or sell thus choosing an inappropriate stock	Skill base - Perceptual Confusion - Accepting look-alikes, or wrong things in the proper location	a) oft-repeated routine tasks b) unusual or unexpected stimuli - time pressure and stress	12	12
12	Writing the incorrect customer number thus proceed with the execution of an order for the wrong customer	Skill base - Perceptual Confusion - Accepting look-alikes, or wrong things in the proper location	a) oft-repeated routine tasks b) unusual or unexpected stimuli - time pressure and stress	3	3

The full analysed ratings of both interviewers on likelihood and impact of each error, are presented below.

Interviewers scores on likelihood and severity of errors

Risk Rating: Likelihood x Severity	1-3 Low Risk	4-6 Medium Risk	7-9 High Risk	10-16 Very High Risk

INTERVIEWER 1

	ERRORS	Likelihood	Impact	Risk Level
1	Ticking a wrong box on the questionnaire by mistake - wrong data will be analysed on later stage- IPS will not be correct	3	2	6
2	Writing wrong contact details of customer like email or phone - later issues when the customer will be missing important newsfeed /related information about his portfolio	4	1	4
3	Foreigner customer (not English speaker)- portfolio manager required to use help of translator who might mishear/misunderstand something thus translate it incorrect - the PM will fill wrongly the questionnaire	1	2	2
4	Choose the wrong option from the drop-down list about e.g. about the investor's income, age, risk tolerance, results to the wrong profile - IPS would be totally invalid	3	3	9
5	Inexperienced analyst not following procedures creates a model including inconsistent formulas	2	4	8
6	Inexperienced analyst not following procedures creates a model including incorrect calculations	2	3	6
7	Inexperienced analyst not following procedures creates a model including use of whole numbers instead of percentages or even typos	2	4	8

8	PM making the wrong connection between the above-mentioned events /variables (company's earnings growth, its stability etc) thus selecting risky unprofitable stocks, bonds etc to buy or sell.	1	4	4
9	If a portfolio manager has an order to sell, he must choose the correct button by unselecting the default 'buy' button and select 'sell' button. If he forgets to select the correct button, then the whole action will be wrong causing the customer money losses.	2	3	6
10	Stock purchased or sold in incorrect amount or price - Fat Finger error: Writing incorrect amount when entering an order	4	3	12
11	Wrong stock purchased or sold: Ticking/ selecting the wrong stock from the available list to buy or sell thus choosing an inappropriate stock	3	4	12
12	Writing the incorrect customer number thus proceed with the execution of an order for the wrong customer	1	3	3

INTERVIEWER 2

	ERRORS	Likelihood	Impact	Risk Level
1	Ticking a wrong box on the questionnaire by mistake - wrong data will be analysed on later stage- IPS will not be correct	4	2	8
2	Writing wrong contact details of customer like email or phone - later issues when the customer will be missing important newsfeed /related information about his portfolio	4	1	4
3	Foreigner customer (not English speaker)- portfolio manager required to use help of translator who might mishear/misunderstand something thus translate it incorrect - the PM will fill wrongly the questionnaire	3	3	9

4	Choose the wrong option from the drop-down list about e.g. about the investor's income, age, risk tolerance, results to the wrong profile - IPS would be totally invalid	2	3	6
5	Inexperienced analyst not following procedures creates a model including inconsistent formulas	2	4	8
6	Inexperienced analyst not following procedures creates a model including incorrect calculations	1	4	4
7	Inexperienced analyst not following procedures creates a model including use of whole numbers instead of percentages or even typos	2	4	8
8	PM making the wrong connection between the above-mentioned events /variables (company's earnings growth, its stability etc) thus selecting risky unprofitable stocks, bonds etc to buy or sell.	4	3	12
9	If a portfolio manager has an order to sell, he must choose the correct button by unselecting the default 'buy' button and select 'sell' button. If he forgets to select the correct button, then the whole action will be wrong causing the customer money losses.	1	4	4
10	Stock purchased or sold in incorrect amount or price - Fat Finger error: Writing incorrect amount when entering an order	2	3	6
11	Wrong stock purchased or sold: Ticking/ selecting the wrong stock from the available list to buy or sell thus choosing an inappropriate stock	4	3	12
12	Writing the incorrect customer number thus proceed with the execution of an order for the wrong customer	1	3	3

Based on the scores, errors number 2,5,7 and 12 appear to have the same level of risk as well as the same scores for likelihood and impact.

Error number 2, a Skill-based error, appears to have the same medium risk for both interviewers who consider it as a frequent error with an insignificant effect on the project.

Errors number 5 and 7, seem to have the same high-risk level for both interviewers, whilst both of them agree that these are errors which have heard them happening in the industry with a catastrophic effect on a project.

Error number 12 which is a Skill-based error, appears to have the same low risk rating for both interviewers, who believe that it is possible for this error to occur whilst its impact can be critical with damaging effect on a project.

Some errors like 6,9 and 11 have the same risk level for both interviewers but with different views on the likelihood and impact.

Errors number 6 and 9, are considered for both interviewers as medium risk with interviewer 1 suggesting that these are errors likely to happen as it has heard them happening before, whilst interviewer 2 believes these are just possible errors that probably could happen. Interviewer's 1 view on the severity of these errors, is that they have critical effect on a project whilst interviewer 2 believes that these are errors with catastrophic impact on the project.

Skill based Error number 11, appears to be one of the very high-risk errors. Interviewer 1 said that it is an error that happened to him as well whilst interviewer 2 claims that it is a frequent error occurring regularly. The severity of this error according to Interviewer 1 though is catastrophic whereas according to Interviewer 2 it is critical.

Although Skill-based Error number 1 has been assessed to have moderate impact by both interviewers, their views on its likelihood and thus the risk level differ. For Interviewer 1 this is an occasional error that happened to him before but for Interviewer 2 this considers to be a frequent error.

Interviewers' perspective on Skill-based error number 3 appears to be significantly different. For Interviewer 1 this is a Low risk error whilst for Interviewer 2 it is a High-risk error. Interviewer 1 considers the likelihood of this error as possible and its severity as moderate. On the contrary Interviewer 2 rated both likelihood and impact as an occasional error with critical effects on the project.

The risk ratings for Skill based error number 4 are relatively different as for Interviewer 1 it is considered as High – risk error but for Interviewer 2 a medium risk error. Both of them agree on the level of impact and they believe it may have a critical damaging effect

on a project. As for the likelihood, Interviewer 1 believes it happens occasionally, but Interviewer 2 believes it is likely to happen as he heard it happened before.

Error number 8 is a Knowledge-based error and also an error with significantly big difference in risk rating by the interviewers. For Interviewer 1 this is a Medium risk error but for Interviewer 2 it is a Very high risk one. Though Interviewer 1 believes that it is a possible error that could happen, on the contrary Interviewer 2 believes it is a frequent error. The impact of this error though is considered as catastrophic for Interviewer 1 and critical for Interviewer 2.

Another error with substantial difference in risk rating is error number 10, a Skill-based error. For Interviewer 1 it turns to be one of the Very High-risk errors whilst for Interviewer 2 it is just a Medium level risk, although both of them agree that the error's impact is critical. Their views on the likelihood though differ as Interviewer 1 believes it is a frequent error whilst Interviewer 2 believes it is an error likely to happen.

As mentioned before, human error is impossible to completely eliminated. What is possible is to limit the risk and effect of human error. In order to do this, interviewers were asked their views on how to minimise human errors and solutions for the conditions that cause human errors were discussed. The results are breakdown as follows at figure 6.

Figure 6: Errors-Conditions - Measures

	ERRORS	CONDITION	MEASURES
1	Ticking a wrong box on the questionnaire by mistake -wrong data will be analysed on later stage- IPS will not be correct	Skill base: a) oft-repeated routine tasks b) unusual or unexpected stimuli - repeated/boring actions, monotony	1. Automate the procedure 2. Cross-train employees and rotating jobs to reduce levels of boredom 3. System of reward and recognition of good work so employees re-motivated 4. Good communication between managers and employees 5. Regular breaks 6. Team cross-checking of information
2	Writing wrong contact details of customer like email or phone - later issues when the customer will be missing important newsfeed /related information about his portfolio		
3	Foreigner customer (not English speaker)- portfolio manager required to use help of translator who might mishear/misunderstand something thus translate it incorrect - the PM will fill wrongly the questionnaire		

4	Choose the wrong option from the drop-down list about e.g. about the investor's income, age, risk tolerance, results to the wrong profile - IPS would be totally invalid	Skill base: a) oft-repeated routine tasks b) unusual or unexpected stimuli – emotional, physical and mental fatigue	1. Redesigning and simplifying tasks / eliminating unnecessary, wasteful steps through automation of systems that reduces human involvement in the task 2. Reviewing maximum hours of working 3. Better work environment: good humidity system, better lighting, ergonomic work area design, good acoustic system
5	Inexperienced analyst not following procedures creates a model including inconsistent formulas	Skill base: two simultaneously active plans or actions competing for attention - pressure, fatigue, noise interaction	1. Appropriate work delegation for appropriate deadlines 2. Provision of healthy and comfortable space: ergonomic chairs, appropriate lighting and computer monitors with reduced glare for min eyestrain 3. Regular breaks to refresh
6	Inexperienced analyst not following procedures creates a model including incorrect calculations		
7	Inexperienced analyst not following procedures creates a model including use of whole numbers instead of percentages or even typos	Rule base: a) Many parameters b) Limited experience - lack of experience, knowledge, abilities	1. Writing better, clear procedures 2. Provision of all needed information for the task 3. Restructuring of the task 4. Constantly educating and training employees tailored to their job-specific roles
8	PM making the wrong connection between the above-mentioned events /variables (company's earnings growth, its stability etc) thus selecting risky unprofitable stocks, bonds etc to buy or sell.	Knowledge base: a) existence of potentially covariating factors, b) theories for or against the potential covariation - wrong assumptions support patterns that do not actually exists	1. Introducing better digital investment advisory tools to choose the appropriate stocks/bonds 2. Continuously educated from training courses, trading mentors, studying

9	If a portfolio manager has an order to sell, he must choose the correct button by unselecting the default 'buy' button and select 'sell' button. If he forgets to select the correct button, then the whole action will be wrong causing the customer money losses.	Rule base: A wrong rule whose vast majority of aspects are coincidently right - distractions/ noisy environment	1.Environmental design changes, especially to improve alertness: appropriate temperature, lighting and comfort levels 2. Small Offices 3. Use of headphones
10	Stock purchased or sold in incorrect amount or price - Fat Finger error: Writing incorrect amount when entering an order	Skill base: a) oft-repeated routine tasks b) unusual or unexpected stimuli - time pressure and stress	1. Setting prevention filters on the platform if transaction of buying or selling is exceeding a specific volume amount 2. Using automated systems to recognise trades that don't conform to the usual size by a significant margin 3. Reviewing maximum hours of working and overtimes 4. Clearly communicating project priorities 5. Hire sufficient staff to help with workload
11	Wrong stock purchased or sold: Ticking/ selecting the wrong stock from the available list to buy or sell thus choosing an inappropriate stock		
12	Writing the incorrect customer number thus proceed with the execution of an order for the wrong customer		

Based on the results of this study, we can't clearly suggest that the level of risk is associated with the type of the tasks – skill, rule, knowledge. What is clear though is that most of the human errors are skill-based, which means that humans are prone to slip and lapse with familiar tasks.

The use of automation is many ways, appears to be one of the strongest measures for many of the errors. Automation of a procedure is considered to be less boring and monotonous by the interviewers thus less prone to errors. By the use of automation, tasks can be redesigned and simplified to eliminate any unnecessary and wasteful steps that cause inattention errors since they are reducing human involvement in the task.

Also, by Introducing better digital investment advisory tools to choose the appropriate stocks/bonds or setting prevention filters on the platform if transaction of buying or selling is exceeding a specific volume amount and to recognise trades that don't conform to the usual size by a significant margin, many of the abovementioned errors can be avoided.

Moreover, the working environment is considered by the interviewers a key factor for the prevention of errors. A comfortable and healthy environment can be achieved by a good humidity system, better lighting, ergonomic work area design, good acoustic system and even a nice decoration of the offices. These will help employee's ability to work accurately.

Furthermore, it is important that employers are reviewing maximum hours of working and overtimes of their employees and also that they are clearly communicating project priorities and they delegate work appropriately for appropriate deadlines or hire sufficient staff to help with workload. That way, they are minimising the stress and time pressure of their employees who would otherwise be pushed past their capacity, work too fast, tiring too quickly and then making more mistakes.

Chapter 5

Conclusion

The main objective of this study was to provide an analysis of the risk perception and human error risk management in investment management sector and specifically in portfolio management. The literature review was limited to the human error-unintentional behavior, the human error models, and the human error as well as on the risk perception, the risk perception models and the risk perceptions in the investment management sector.

Since empirical research regarding human factors and risk on portfolio management process is lacking, the principal goal of the Thesis is to deliver a pilot study introducing this aspect. Then to provide specific prevention measurements for the errors found in this study.

Various factors can influence our risk perceptions and risk attitudes. Risk analysis and identification are the fundamental steps in risk management.

The study used James Reason's Generic Error Modelling System (GEMS). The aim of GEMS is to describe how switching occurs between the different types of information processing (skill, rule, knowledge) in tasks. GEMS is a simple way to capture most indicators of human error and also facilitates the search for methods of error correction. Slips and lapses are considered involuntary actions that deviate from planned intentions resulting in not reaching their goals. Mistakes and violations are considered intentional actions since they are performed consciously but the desired result is not achieved.

The portfolio manager has daily tasks that range from, the Planning tasks, Execution tasks and Feedback tasks that include among others managing and creating investments allocations for customers, formulation of the investment policies, determination of the strategic asset allocations, management of client's transactions, interviewing of the clients with the aim of ensuring that the needs are met and they are understood.

The above-mentioned as well as the many other tasks are classified into 3 tenets; The first is the skilled based, it is a routine behaviour predicated on learning skills for which the cognitive commitment is very low and reasoning is unconscious or automatic. The second espouses the ruled based concept where the person recognizes the situation and applies the right procedure to perform the task, and then performs a series of actions by the use of procedures. In this case the person follows remembered or written rules, cognitive engagement. The third and final one is the knowledge-based which is about improvisation in unfamiliar environments, no procedures or rules available for handling

situation, reacting based on the information available and the knowledge gained in a completely conscious manner.

Portfolio management is a complex and risky domain, including tasks where stakeholders need to make high-stakes decisions within complex, large, noisy, high-pressured, and technologically advanced environments. As Leaver notes financial trading is increasingly conceptualized as similar to a high-risk industry with risk constantly being monitored and, when possible, reduced through improving employee skills and system design (Leaver et al, 2016). Bryce also notes that it is vital that management obtains reliable and accurate information within their own organisation regarding errors, whether they are simple human error, or intentional actions that could have a harmful impact on the company (Bryce et al,2017).

The purpose of this Thesis is to introduce an approach to model the potential forms of errors and the related conditions for each level of performance in two of the portfolio management steps: planning and execution. A pilot study on human factors risk analysis was conducted based on Reason's GEMS classification scheme which facilitates the detection of the error and its correction as well as providing help for mitigation measures. Various tasks of these two steps were framed and there was an effort to conceptualize the conditions under which various errors can be made by the portfolio managers.

A piloted survey questionnaire was sent to two interviewers in order to find out their views on portfolio management tasks possible human errors, the likelihood and the impact these errors may have. As it appears from this pilot study, most of the human errors are skill-based, which means that humans are prone to slip and lapse with familiar tasks.

The Perceptual Confusion is one of the mechanisms producing slips as identified by Reason and appears when someone accepts look-alikes, or wrong things in the proper location in other words when confusing two things that look or sound alike. The mechanisms needed to simulate this skill performance error is attention or better inattention. As Busse wrote ''*in a routine set of actions, it is unnecessary to invest the same amount of attention in the matching process*'' (Busse, 2002).

We can see that most of the abovementioned errors (1,2,3,4,10,11,12) are considered to be Perceptual confusion errors. As previously mentioned in subchapter 4.2, skill base perceptual confusion errors may arise due to various reasons like repeated/boring actions, monotony, emotional, physical and mental fatigue time pressure and stress.

The combination of time pressure, dynamic conditions, and heavy information load resulted by serious situations provides fruitful ground for error. Better training, reducing interruptions and multitasking are methods for reducing slips and individuals should be aware of risk-enhancing factors in interactive work.

Organizations should express to employees how valuable the information is and how inaccuracy can negatively affect the business so they will try to avoid data entry errors. If employees are feeling more responsible for the data, then automatically this will improve their overall effectiveness and accuracy.

Another solution to fight perceptual confusion errors is by hiring sufficient staff. No matter how capable and efficient the employees of an organisation might be, they still have their limits like every human being. By pushing them past their capacity or by overworking they are prone to commit mistakes.

Moreover, entering information can be a time-consuming process for an employee. By reducing the amount of useless data need to be inputted in the system, it may reduce the chances to input errors. Any redundant or unnecessary forms should be eliminated so that the possibility for double-entry can be avoided since employees will have to process less data. Software tools could be also a solution, including automatic error reports, can check the input data to make sure it fits specified parameters where upon an error, a pop-up on the system can alert the employee to fix it immediately.

Interference errors (5+6) from inattention, due to pressure, fatigue, noise and interaction is another mechanism for creating slips identified by Reason, occurring when multiple active schemas become confused.

Work should be delegated appropriately while allowing for appropriate deadlines, so employees don't feel rushed and pressured. Moreover, the organization should be able to provide its employees with a healthy and comfortable and space like ergonomic chairs, appropriate lighting and computer monitors with reduced glare so that the eyestrain will be minimised, consider offering them regular breaks to refresh and reset before they return to work etc.

At the Rule base performance, application of bad rules occurs from error mechanisms related to the elaboration of these rules. Encoding deficiency errors (part of application of bad rules mode) occur when certain properties of the problem space are not encoded at all due to inadequate perceptual coding to human beings. It is about individual's failure to successfully interpret available information. As Charles wrote ''*This is done by either missing crucial information completely, or by the misinterpretation of existing data by a decision-maker causing him or her to respond in a certain, albeit, incorrect, manner*'' (Charles, 2000). Encoding deficiencies should be minimised by restructuring of the task so it becomes clear to employees, by writing better procedures and constantly educating and training employees. Learning from past experience is also an idea of how this kind of errors can be avoided. Organizations could review their failures and successes by assess them systematically and record them in a way that is accessible to the employees. That way could think about the past and learn from previous mistakes.

Knowledge base illusory correlation errors (8) due to missed or mistaken covariation are often happening where decisions are made with limited information and faulty assumptions. People often tend to overestimate the importance of can easily recalled events and underestimate the importance of events that are hard to recall. In the case of portfolio managers, usually they believe they have fund patterns that do not actually exists, and they persist on them ignoring any contrary evidence.

As in this thesis case, Bender and Simon in their research work explain how traders sometimes use the 'head-and-shoulders' chart to predict price movements. Their explanation is ''*It's when the stock's price movement looks like a person's head and shoulders: in other words, two smaller peaks with one big peak in between*''. Although this might be considered as reliable signal and associated with increased trading, the head-and-shoulders shape on the chart doesn't profitably predict price fluctuations (Bender et al, 2012).

The issue of illusory correlation could be minimised with various solutions. By introducing digital investment advisory tools to choose the appropriate stocks or employ unbiased, third-party experts could be proven helpful to eliminate potential mental errors. Also, by developing a money management plan, the portfolio managers could define how much money they are willing to risk on any trade. Moreover, portfolio managers should continuously get educated from courses, trading mentors, studying etc so they can have a general understanding of the trading and also by examining the actual data available so they can run the numbers.

When at Rule base performance, Action deficiency errors may occur as in the case of this study (error 9), since the actions chosen are inappropriate (wrong rules). Task procedures are pre-determined solutions to possible work situations that require specific responses that employees should follow, where applying the wrong response to a work situation can lead to an error. Distractions and noisy environment appear to cause action deficiency errors since distraction is a state characterized by a lack of clear and orderly thought and behaviour. Confusion is also one element of distraction.

The work environment plays a major role in the Rule based performance. An environment that is too hot, too cold, the poor lighting may lead of errors. Open plan offices rather than boosting productivity provide range of distractions which means that employees are interrupted often. Smaller offices and the use of headphones could minimise the noise and could make employees more focus.

The patterns of error identified in this pilot study could be used for future exploration and in more depth many other everyday errors in the portfolio management tasks and how they can be avoided.

Appendices

Appendix A: Questionnaire given to research participants

The planning step: The first thing a portfolio manager does is to discuss with the client in order to understand his investment objective, goal and level of risk the customer is willing to take. Thus, after the agreement with the customer the investment objectives and policies are formulated, constraints are determined, capital market expectations are formed, and strategic asset allocations are established and an investment policy statement is created (Maginn et al,2018). An investment policy statement is a formal document between the portfolio manager and the client which clearly sets the investor's goals, objectives and constraints. It allows the investor to determine the factors that are personally important and should be reflected in the investment plan and without it the success of a financial plan is at risk (Reilly et al. 2002 :53). The failure to follow an investment policy statement is evidence of a breach of fiduciary responsibility.

The execution step: After the planning step comes the construction and implementation of the portfolio. The manager together with the investor determine how to allocate the available funds across their options (bonds, stocks, securities etc). The portfolio selection/ composition should minimise the investor's risk as well as meeting the investor's needs according to the policy statement. The next step in the process is to implement this portfolio. What is important to be noted in this step is that high transaction explicit and implicit costs like taxes, fees, commissions, bid-ask spread, opportunity costs, market price impacts, etc. can reduce the performance of the portfolio. Hence, the execution of the portfolio needs to be appropriately timed and well-managed (Olssen,2005).

The feedback step: after the funds are invested according to the plan, the manager monitors, evaluates and update the portfolio compared with the plan. The managers must continually monitor the investor's needs and the capital market conditions so that they can evaluate the portfolio's performance and compare the relative results to the expectations and requirements of the policy statement. Any changes, updating and rebalancing suggested by the feedback must be examined carefully to ensure that they represent long-run considerations.

Interview Questions

1. According to the description of the portfolio manager process, can you define the daily tasks of a portfolio manager?

2. Table 1, shows some human errors a portfolio manager is exposed to during some tasks and the conditions related for every error. Do you agree with these statements?

3. Do you suggest any additional human errors that are possible to happen and under what conditions?

4. Please rate (in table 2) for every error the likelihood of happening (1-Prossibly : Probably could happened, 2- Likely : Heard of in the industry, 3-Occasional :Has happened to me, 4- Frequent : Occurs regularly) and their impact (1- Insignificant :Small or no effect on the project, 2- Moderate : Unlikely to cause damage or threaten the survival of the project, 3-Critical: Likely to cause some damaging effect on the project, 4- Catastrophic : Threatening for the survival of the project).

5. What are, in your opinion, the solutions to minimise these human errors?

Table 1

	ERRORS	CONDITION
1	Ticking a wrong box on the questionnaire by mistake - wrong data will be analysed on later stage- IPS will not be correct	a) oft-repeated routine tasks b) unusual or unexpected stimuli - repeated/boring actions, monotony
2	Writing wrong contact details of customer like email or phone - later issues when the customer will be missing important newsfeed /related information about his portfolio	a) oft-repeated routine tasks b) unusual or unexpected stimuli - repeated/boring actions, monotony
3	Foreigner customer (not English speaker)- portfolio manager required to use help of translator who might mishear/misunderstand something thus translate it incorrect - the PM will fill wrongly the questionnaire	a) oft-repeated routine tasks b) unusual or unexpected stimuli - repeated/boring actions, monotony

4	Choose the wrong option from the drop-down list about e.g. about the investor's income, age, risk tolerance, results to the wrong profile - IPS would be totally invalid	a) oft-repeated routine tasks b) unusual or unexpected stimuli – emotional, physical and mental fatigue
5	Inexperienced analyst not following procedures creates a model including inconsistent formulas	two simultaneously active plans or actions competing for attention - lack of experience, knowledge, abilities
6	Inexperienced analyst not following procedures creates a model including incorrect calculations	two simultaneously active plans or actions competing for attention - lack of experience, knowledge, abilities
7	Inexperienced analyst not following procedures creates a model including use of whole numbers instead of percentages or even typos	a) Many parameters b) Limited experience - lack of experience, knowledge, abilities
8	PM making the wrong connection between the events /variables (company's earnings growth, its stability etc) thus selecting risky unprofitable stocks, bonds etc to buy or sell.	a) existence of potentially covariating factors, b) theories for or against the potential covariation - wrong assumptions support patterns that do not actually exists
9	If a portfolio manager has an order to sell, he must choose the correct button by unselecting the default 'buy' button and select 'sell' button. If he forgets to select the correct button, then the whole action will be wrong causing the customer money losses.	A wrong rule whose vast majority of aspects are coincidently right - distractions/ noisy environment
10	Stock purchased or sold in incorrect amount or price - Fat Finger error: Writing incorrect amount when entering an order	a) oft-repeated routine tasks b) unusual or unexpected stimuli - time pressure and stress
11	Wrong stock purchased or sold: Ticking/ selecting the wrong stock from the available list to buy or sell thus choosing an inappropriate stock	a) oft-repeated routine tasks b) unusual or unexpected stimuli - time pressure and stress
12	Writing the incorrect customer number thus proceed with the execution of an order for the wrong customer	a) oft-repeated routine tasks b) unusual or unexpected stimuli - time pressure and stress

Table 2

		Likelihood			
		1- Possibly: Probably could happened	2- Likely: Heard of in the industry	3 - Occasionally: Has happened to me	4 - Frequently: Occurs regularly
Severity	1 - Insignificant: Small or no effect on the project				
	2 - Moderate: Unlikely to cause damage or threaten the survival of the project				
	3 - Critical: Likely to cause some damaging effect on the project				
	4 - Catastrophic: Threatening for the survival of the project				

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