



University of
Strathclyde
Business
School

**Revisiting Ansoff's weak signal theory – Exploring the effects of
machine learning on filters of weak signals**

by
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This thesis is submitted in partial fulfilment of the requirements for the
degree of Doctor of Philosophy in the Hunter Centre for Entrepreneurship at
the University of Strathclyde.

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Signed:

A handwritten signature in blue ink, consisting of a stylized, cursive script that is difficult to decipher but appears to be a personal name.

Date: 28th February 2025

Conference Publications

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Dedication

This doctoral thesis is dedicated to Appa, Amma, Champa, and my dears Virat and Vihas.

Acknowledgements

My journey during my PhD has been quite a dynamic one. As complexity theory suggests, there have been various actors and agents that have interacted with me and enabled me to complete this journey. Considering this complexity, it would be impossible to acknowledge every action and person here. So, I would like to thank everyone who have influenced me, either directly or indirectly, through this journey. But some people have had a direct impact on my thesis, and I would like to explicitly acknowledge their influence. Firstly, I would like to thank the Gods to have designed the complexities of life to work in a manner that has enabled me to reach thus far.

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Having said this, and irrespective of the support I have received, any shortcomings in this thesis is, of course, my own.

Vivek Venugopal
Wokingham, UK
February 2025

"People worry that computers will get too smart and take over the world, but the real problem is that they're too stupid and they've already taken over the world."

– Pedro Domingos

Abstract

Strategic foresight is an important managerial activity to develop coping strategies for future uncertainties. Ansoff in the 70s proposed weak signals theory to manage uncertainties. The literature on Ansoff's weak signals has seen an increase in recent years. It is argued that weak signal analysis can aid an organisation to weather disruptions and remain competitive. As disruption are preceded by subtle signals called weak signals. By monitoring, detecting, amplifying, and reacting to these signals, organisations can adapt to the dynamic environment and be relevant in the long term. This is where forecasting tools fail as it is impossible to forecast into long term future. But the research in this field is in its infancy compared to other fields such as scenario planning or more broadly strategic management.

This research reviewed the extant literature on weak signals through a systematic literature review and identified the current research gaps. Based on the research gaps found, a research agenda was set to explore how machines enhance the detection and alter the perceiving of weak signals (filters of weak signals). Through the lens of pragmatism, this research adopted a multi methods approach. The methods included semi-structured interviews, participant observation, and Miro board observations.

The findings from the research showed that it does not seem that machines can enhance weak signal detection. But there is a nuance to this, as the value of AI output depends on who the user is. If an expert is using it, then perhaps not as they seem to contain information already known. But if it is a novice who is using AI then there seems to be value in the output. Filters of weak signal do remain even with the use of machines. It also seemed that machines amplified filters. Findings from the research allowed for contribution to practice such as, foresight experts need to up-skill with respect to AI. And prompt engineering is an important skill required whilst using AI models such as LLMs.

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List of abbreviations

| Abbreviation | Full form |
|--------------|---|
| AI | Artificial Intelligence |
| GT | Grounded Theory |
| HS | Horizon Scanning |
| IL | Intuitive Logics (Scenario planning) |
| IPA | Interpretative Phenomenological Analysis |
| LDA | Latent Dirichlet Allocation |
| ML | Machine Learning |
| NLP | Natural Language Processing |
| LLMs | Large language models (AI) |
| Gen AI | Generative AI or General artificial intelligence depending on context |
| RQ1 | Research Question 1 |
| RQ2 | Research Question 2 |
| SBS | Strathclyde Business School |
| SF | Strategic Foresight |
| SLR | Systematic Literature Review |
| SP | Scenario Planning |
| TA | Thematic Analysis |
| WS | Weak Signal(s) |

WST

Weak Signal Theory

Clarifications on terminology used

Scenarios(s) is sometimes used in place of **Scenario planning**. The two terms are used interchangeably in this thesis. In all cases, the terms, scenario planning and scenario(s), refer to Intuitive Logics scenario planning method.

The word **Machine(s)** is used instead of **machine learning and AI** in various parts of the thesis. But the word, machines, when used, refers to machine learning or AI within the context of this thesis. The two terms are used interchangeably within this thesis. The machine learning algorithm used in this thesis is the Latent Dirichlet Allocation (LDA). The word machine(s) or the term machine learning within this thesis will always refer to the Latent Dirichlet Algorithm or Large Language Models. Except, when there is an explicit mention of other algorithms.

Due to the context in which the data was gathered for this thesis, the words **Drivers** and **Weak signals** are used interchangeably. For this research, it is assumed that the drivers identified within scenario planning activity either contain weak signals or they are weak signals. There is no explicit differentiation made between the two terms.

1. Introduction

The Oil crisis of the 1970s forced organisations to reconsider their forecasting techniques. The prevailing forecasting techniques at that time were statistical growth projections based on the foundation of past data. These techniques or methods considered that the future would continue in the same linear manner Ansoff (1975). But the future is not the same as the past and the top management's tendency to depend on hard data makes the spotting of disruptive changes extremely hard. Not just the 1970s, but throughout the business history there is no dearth of examples of great businesses that have fallen because they were unable to react to disruptive changes in their playing field.

But it is quite a conundrum that even though this fact of turbulence is evident, and signals of this turbulence is floating in the air, the acceptance of weak signals theory is sparse. Though this view is changing due to recent developments such as globalisation, interference of geopolitics in global economy, and eventual interconnection of multiple factors. More recently, the pressure for net zero carbon emission, and various other challenges have cropped up due to the climate change. These factors have made the traditional measures of the market, such as market share, not valid as an incumbent can easily be dethroned by a disruptive young company (Prahalad, 1995).

The market has also moved from a 'transactional exchange' based market where the operational efficiency, economies of scale, etc., were given preference. The business operation was simple during 'transactional exchange' markets as the operations were, purchase, fabricate, advertise, and sell. But today's business environment is different and is prone to

disruption and thus the traditional way of doing business will not work (Ansoff, Kirsch and Roventa, 1982;Ansoff, 1985). The alternate to this is by monitoring and reacting to turbulence by identifying clues of impending change called weak signals (Ansoff, 1975)

Ansoff states that "A weak signal is an early indication of a change whose impact is expected to be very significant, but the mechanism of impact cannot be described accurately enough to permit management to device a specific "strong" response, or to compute the size of an impact". (Ansoff, Kirsch and Roventa, 1982, Pg 240).

Ansoff is known as a pioneer in long range planning. He was also seen as the proponent of the 'strategic planning school' as credited by Mintzberg in a heated exchange of thoughts published in the Strategic Management Journal (Ansoff, 1991;Mintzberg, 1991). Through his various works, importantly his book 'implanting strategy' and 'corporate strategy', Ansoff advocated the identification of weak signals and emerging events, develop scenarios, and responding (graduated response) on the signals. Even though this is similar to strategic foresight, Ansoff is not seen as the father of strategic foresight studies as Ansoff's focus was on strategic management (Martinet, 2010). But nonetheless, Ansoff's research and contribution has a profound impact on strategic foresight, a concept which will be presented in the next chapter.

The disruptive and turbulent business environment have garnered more importance to weak signals (WS) (Rossel, 2011;Bereznoy, 2017). When one the author of this thesis spoke to a consultant, the consultant said that since COVID the big fours (well-known consulting companies) and other consultancies are actively investing and considering scenario planning and weak signal methods. But it is still surprising that many organisations, even after so many years since the WS theory was put forward, yet depend on complicated and expensively computed forecasts for deciding on the future

direction of their business organisation (Amanatidou et al., 2012). The problem with complicated models is that they are good with past data but do not perform well with new data. Examples such as blockbusters failure due to the arrival of Netflix, Kodak's failure to recognise digital future of photography etc., stand tall as reminders of how businesses could not cope with disruptive changes.

The claim that the business environment is turbulent, and the drawbacks of traditional forecasting methods can be seen in the literature from past few decades. Yet even recent literature seems to present this turbulent environment as something that belongs to the present. As MacKay and McKiernan (2018, Pg 01) state "But it (business environment) was ever thus (turbulent)". From the time of research output of Ansoff (1975) about weak signals citing the example of the oil crisis; many incidents such surprising events have occurred – e.g., the 2008 financial crisis, and more recently the COVID crisis. Thus, the business environment is synonymous to turbulence and the business environment is extremely dynamic.

There is a good amount of research on the various tools and methods scanning systems which aid in spotting the turbulence. The cause of the turbulence is known by many names such as: wild cards and black swans (Christianson et al., 2008) but more generally referred to as rare events. Research on rare incidents invariable involved weak signals and early warning systems to anticipate these incidents as well as to spot changes in the environment. Many scholars building on Ansoff's early warning systems for detecting weak signals for strategic planning, have researched, and established well founded concepts. Some examples are "scenario planning" (For e.g., see: Van der Heijden *et al.*, 2002; Cairns, 2018; MacKay and McKiernan, 2018), horizon scanning (Miles and Saritas, 2012; Hines et al., 2018), and peripheral scanning (Day and Schoemaker, 2005). The principles on which these concepts are based have developed into a separate field

called Strategic foresight. And the common notion underlying these fields is that " [The] ability to be or to become sensitive to trends and weak signals leads to greater attention, availability, willingness and readiness to listen and respond strategically and innovatively to internal and external changes in the PEST environment" (De Toni et al., 2017, Pg 152).

As it can be seen, all the concepts of scanning, within strategic foresight methods, use weak signal theory either implicitly or explicitly. This research, thus, views weak signals nested within the context of scenario planning. Since scenario planning is one of the methods of strategic foresight, a brief overview of strategic foresight and scenario planning is presented the following chapters. Post this, the conceptual framework for this thesis is derived and presented for ease of understanding this research. Before proceeding to the next chapter, the research purpose including the research questions, and the structure of the thesis is presented below.

1.1. Research purpose

Even with the advancement of research on various concepts within strategic foresight, which involves weak signals invariably, the weak signal theory itself has not been actively revisited using the context of technological advancements. As mentioned in the earlier part of this introduction, technological advancements and interconnectedness of the world have increased the turbulent and dynamical nature of the business environment. Thus, through this thesis, the researcher aims to revisit Ansoff's weak signal theory to explore how machine learning (and AI) enhances the detection and alters the perceiving (filters) of weak signals. Considering the recent turbulence caused by events such as COVID-19, Brexit, etc., this thesis sits in the right context for researching on weak signals theory. As the findings from

this research would not only have implications for the theory but on the practical application of weak signals as well.

To guide this aim of the thesis the following research questions were developed from a literature review on weak signals:

RQ1: How can Artificial Intelligence or Machine Learning enhance weak signal detection?

RQ2: How can Artificial Intelligence or Machine Learning alter the process of perceiving weak signals in the context of filters of weak signals?

Whilst answering the above questions, to ensure that a logically structured and readable research is presented, the thesis is structured as presented in the next section.

1.2. Structure of the thesis

Within this thesis, each chapter begins with a brief introduction and concludes with a brief summary. This is done to ensure the chain of flow of thought is maintained and to keep the reader engaged.

Chapter 1 – Introduction

This is the present chapter introduction to the weak signal theory along with some key arguments with respect to this theory are presented. The research purpose and the research questions are introduced in this chapter.

Chapter 2 – Conceptual background to the weak signals theory

This chapter sets the context for this thesis by presenting a brief introduction to strategic foresight and scenario planning. This chapter also sets the stage for the systematic literature review on weak signals in the next chapter.

Chapter 3 – Systematic literature review – Weak signals concept

In this chapter, the details of the systematic literature review are presented. This includes the method and synthesis of the extant literature. From the analysis of the literature, the research questions are developed which the research agenda is established. The research framework is also presented in this chapter.

Chapter 4 – Overview of Research Methodologies in Business and Management

This chapter presents the overview of various philosophical views within the research methods of business and management studies. This chapter also introduces the typical methodologies and the typical methods within the business and management research.

Chapter 5 – The research design

The philosophical stance of this thesis is presented along with the rationale for the choice. This thesis looks at the research through the lens of pragmatism. The various types of theoretical inference are presented and the rationale for the choice of inference, Abduction, is presented. Finally, the choice of method – case study, is presented.

Chapter 6 – The case study design

In this chapter the various aspects that goes into designing a good case study is presented. The choice of case study – multiple case study, is presented. The unit of analysis which is an important aspect of research is also presented within this chapter.

Chapter 7 – Introduction to the cases

The background information on the cases is presented in this chapter to provide the right context to the reader. This includes case 1 – SBS2035 scenario planning project and group observation; case 2 – EIBE (MBA) students Miro board observation and interviews; Expert interviews. For each case, the respective data collection methods along with the timeline of data collection are presented.

Chapter 8 – Data analysis case 1

In this chapter, the analysis for the data collected for case 1 is presented. Descriptive summary of the survey; thematic analysis of the interviews; and analysis on group observations are presented.

Chapter 9 – Data analysis case 2

Moving from case 1, this chapter presented the analysis of data for case 2. Thematic analysis of interviews is presented. Observations from Miro boards of MBA students alongside machine learning output are presented.

Chapter 10 – Data analysis Expert interviews

In this chapter, thematic analysis of the expert interviews is presented

Chapter 11 – Cross case analysis and answers to research questions

This chapter brings together the analysis from the three cases. And provides answers to the research questions set out in this thesis.

Chapter 12 – Discussion and contribution

In this chapter, the contribution to theory and practice are presented. Apart from this an evaluation of the research quality of this thesis against standard criteria is presented.

Chapter 13 – Conclusion

This is the final chapter where the conclusions of this research are presented. This is done by summarising the whole research process and by presenting a concise summary of the research findings. Within this chapter, the limitations of this thesis are acknowledged, and future research aspirations are presented. This is the final chapter and conclusive chapter before the bibliography and appendices

Chapter conclusion

In the chapter, the introduction to this thesis was provided along with the research aim. The structure was presented as part of the introduction. In the next chapter the conceptual background of weak signals, strategic foresight and scenario planning, will be presented.

2. Conceptual background to the Weak signal theory

In the previous chapter an introduction to the thesis was presented along with the research purpose, research questions, and thesis structure. As mentioned earlier, the research aims of this thesis is to explore how machines can enhance weak signal detection. And how machines alter the filters of weak signals. Weak signals are sought and analysed during the empirical information gathering stages within various frameworks of strategic foresight – for e.g., horizon scanning or scenario planning. As Mendonça, Cardoso and Caraça (2012) state, weak signals are an important source of raw material for strategic foresight. This research in this thesis is set in the context of scenario planning – a deeper explanation of the context is presented in later chapters. Thus, this chapter provides a brief introduction to the conceptual backgrounds on strategic foresight and scenario planning.

2.1. Strategic foresight

The human civilisation has always been involved in foresight and prediction either as a tool for survival or for power and for displaying the legitimacy for the power. As MacKay and McKiernan (2018, Pg. 07) state “Active thinking, analysis, and prediction of future-borne threats and opportunities that both endanger survival and promote prosperity, have constantly challenged the intellectual life of civilisation”. This, they claim, is because the past is “inextricably” linked to the present. And this influences our understanding and imagination of potential futures.

The '*The Art of War*', believed to be written in the 5th Century B.C., by Sun Tzu places importance on knowing or 'foreknowledge'. Strategic games such as Chess and Go, which are centuries old, encourage anticipative and futurist

thinking in order to win. Thus, the human society has always been practicing 'foresighting', albeit, as mystical horoscope prediction and, progressively, for strategic purposes. But the term "foresight" with respect to the business and management studies is very recent. The first-time use of the word has been credited to one of the famous British science fiction novelists, H. G. Wells. He is credit for using the term during a BBC broadcast in 1932 (Kuosa, 2011b). But the term gained traction in terms of usage from the 1980s. The roots of foresight can be traced back to think tanks such as RAND, military technology foresight and military strategies (particularly of the US) in the 1940s and 50s (Kuosa, 2011b).

The FOREN report (European Commission; Research Directorate General, 2001, Pg. v) defines foresight as "Foresight is a systematic, participatory, future-intelligence-gathering and medium-to-long-term vision building process aimed at present-day decisions and mobilizing joint actions. Foresight arises from a convergence of trends underlying recent developments in the fields of 'policy analysis', 'strategic planning', and 'future studies'. It brings together key agents of change and various sources of knowledge in order to develop strategic visions and anticipatory intelligence".

Hines and Bishop (2006 in Kuosa, 2011, Pg. 52) define strategic foresight as "an ability to create a variety of high-quality forward views and to apply the emerging insights in organisationally useful ways; for example, to detect adverse conditions, guide policy, shape strategy; to explore new markets, products and services".

The above two definitions of strategic foresight might seem similar to strategic planning. But the two concepts are different. The FOREN report highlights the difference between foresight and other planning activities by stating that "The difference between Foresight and other planning activities relate to the participative dimension of Foresight. Common features of

foresight include: a long-term orientation, the examination of wide range of factors, the drawing on widely distributed knowledge, the institutionalisation and creation of networks and the use of formal techniques/methods. Formal methods provide more operational results, assess the consistency of different aspects of the vision, help to identify where more knowledge is needed and legitimise the exercise. Foresight is a very evocative label for the rise to prominence of participative methods and long-term strategic futures techniques, in the wake of more traditional ways of informing policy planning” (Kuosa, 2011b, Pg. 10). According to the FOREN report, there are different types of foresight: The bottom-up vs. top-down; product vs. process-orientations; and the examination of expert views vs. consequences. And the foresight approaches are usually a combination of several of these types (Kuosa, 2011b, Pg. 10):

- The first type, top-down exercises, place less stress on interaction and involve highly formal methods such as the Delphi method.
- The second, bottom-up exercises, are more interactive - they take into account a greater number of views, increase legitimacy and yield more process benefits but are more time consuming and more difficult to organize.
- The third, product orientation, is necessary if there is a need to inform specific decisions (a report, list of priorities).
- The fourth, process orientation, is more suitable when there is a lack of networking between key actors.
- The fifth, involves examining and articulating the views of experts.
- The sixth, involves investigating the consequences of future assumptions.

Based on the various approaches to strategic foresight, three steps can be generalised which are common to all foresight processes. The steps are input, foresight, and output (Horton, 1999; Voros, 2003). These are illustrated in figure 1.

Step 1: Input

This is the data collection stage. The methods and tools used can be of different forms such as desk-based research, data mining, trend monitoring, statistical analysis, etc.

Step 2: Foresight

This step is 'translating' and 'interpreting' the input (Kuosa, 2011b, Pg. 57). The translating and interpreting are done by using various analytic methods to analyse, interpret, and prospect based on the inputs from the previous step (Voros, 2003). This usually entails a deep and detailed analysis of the inputs gathered in the previous step (Kuosa, 2011b).

Step 3: Output

In this step the analysis done in the previous work is evaluated and assimilated for aiding in exploring future strategic options. The evaluation and assimilation are iterative in nature so as to create 'forward views' (Slaughter, 1999).

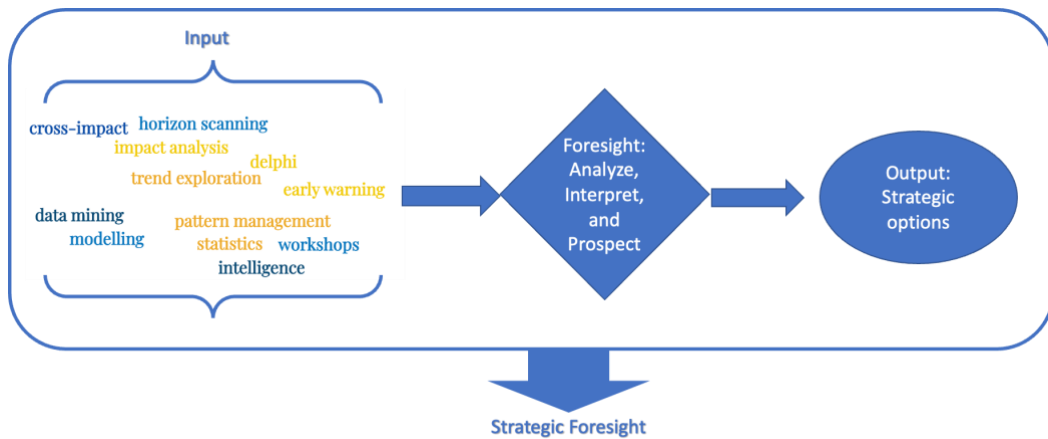


Figure 1: General steps in strategic foresight

Source: Author's own work

Furthermore, Hines and Bishop (2006), similar to the generic steps mentioned above, define six steps of strategic foresight:

- **Framing:** This the first step and this is where the aims, scope, objectives, and focus of the problems are defined.
- **Scanning:** This step involves scanning the internal and external environments for relevant information and trends.
- **Forecasting:** Based on the information from scanning, the drivers, uncertainties, alternatives, etc., are defined. In this step most organizations are tempted to use the past information to project the future and this needs to be challenged.
- **Visioning:** Using the information from forecasting the potential futures are envisioned. This then informs the desired futures that an organisation would like to pursue.
- **Planning:** This is the step where the strategies are formulated to achieve the vision from the previous step.

- **Acting:** The final step is about communicating results, developing action agendas, and institutionalising strategic thinking and intelligence systems.

The general aim of strategic foresight is to make viable options available to decision makers to enable them (decision makers) to remain in power or to win political, military, or economic battles (Kuosa, 2011b).

In this section a brief introduction to strategic foresight was presented along with the general steps involved in it. In the next section a brief introduction to scenario planning will be presented to set the conceptual background for the weak signals theory which is the focus of this PhD thesis.

2.2. Scenario planning

As mentioned earlier, humans have, historically, always used foresight to deal with uncertainty and turbulence in the business environment. One of the tools in foresight is scenario planning and its history can be traced back to the Babylonian celestial science (MacKay and McKiernan, 2018).

The origins of the modern scenario planning lie in the military history. Scenarios were played out through various simulations and war games. For example, 'Chaturanga' – meaning four arms in Sanskrit, which became the modern-day chess, was a board game for war simulation. This game spread from India to Persia, from Persia to the Muslim world and finally from the Muslim world to the continental Europe. Various variations of the chess game emerged across Europe. The most notable was 'kriegsspiel' – meaning war game in German. Many militaries borrowed and adopted this war gaming to train their armies. Thus, much of the 'scenario' thinking was influenced and

focused on the military. The world wars accelerated the acceptance and use of scenarios (MacKay and McKiernan, 2018).

The origins of the present-day version of scenario planning (Intuitive logics) can be found in the works of Herman Kahn (Bishop, Hines and Collins, 2007). Herman Kahn's work came to prominence through his work in RAND (and in turn, US Airforce), especially through his work 'On thermonuclear war'. This work, which was based on using scenarios, was considered so provocative and sensitive that it was not widely circulated till 1960. He later moved on from RAND and established the Hudson Institute for working on public policy (Bradfield et al., 2005).

At the same time as Kahn, the French had developed their own school of thought called 'la prospective'. The man behind la prospective was the French philosopher, Gaston Berger. Unlike Kahn, whose focus was scenarios for the military, Berger's la prospective was for long term political and social future of France. The work of Berger was carried forward by Masse, Jouvenel, and Godet (Van der Heijden *et al.*, 2002).

It should be noted that even though Kahn is widely considered as the father of scenario planning, Berger's work was also taking shape at the same time. But, as MacKay and McKiernan (2018, Pg. 24) state, 'the power of the Anglo-American publishing and media may have promoted Kahn's work to this preeminent state, perhaps (unfairly) relegating Berger's powerful contribution to second place'.

Even though the meaning of the term 'scenario planning' seems obvious, there is no one agreed definition. Further, a wide range of terminologies exists which are used interchangeably such as, 'scenario building', 'scenario techniques', 'scenario thinking', etc. (Varum and Melo, 2010). Also various methods of scenario planning exists such as 'Trend impact analysis (TIA)'

(Chermack, Lynham and Ruona, 2001), 'Causal layered analysis' (Inayatullah, 2008), 'intuitive logics (Bradfield et al., 2005)' etc. In this thesis, the scenario planning method is the intuitive logics scenario planning method.

Table 1: Scenario planning definitions

| Author(s) | Definition |
|------------------------|--|
| Thomas (1994, Pg. 07) | "It is a planning method that systematically experiments with the uncertainties of the future and in so doing, complements and reinforces a company's efforts to become a learning organization." |
| Porter (1985, Pg. 446) | "An internally consistent view of what the future might turn out to be not a forecast, but one possible future outcome" |
| Godet (2000, Pg. 11) | "A scenario is the set formed by the description of a future situation and the course of events that enables one to progress from the original situation to the future situation. Two major categories of scenarios can be identified: (1) exploratory: starting from past and present trends and leading to likely futures; and (2) anticipatory or normative: built on the basis of alternative visions of the future they may be desired or, on the contrary, feared. They have been designed 'retroprojectively' " |

| | |
|---|---|
| Cairns and Wright (2018, Pg. 29) | <p>"Scenario method offers one approach to understanding and analysing seemingly intractable problems where there are 'critical uncertainties' that span a range of subject areas or disciplinary boundaries. It is an approach that is inclusive rather than selective. As such, it can be used in conjunction with, can incorporate information and data from, and can provide input to other methods. It can be used by individuals, but is particularly suited to groups with different organizational, social and disciplinary backgrounds".</p> |
| Van der Heijden <i>et al.</i> (2002, Pg. 02) | <p>"The focus of scenario planning is the capability of organizations to perceive what is going on in their business environments, to think through what this means for them, and then to act upon this new knowledge. It is the need to understand the dots on the horizon, perceiving, thinking and taking action, before it is too late".</p> |

There are multiple definitions of scenario planning as shown in table 1 above. Based on the above definition, the definition by McKiernan (2015, Pg. 01) which integrates and elaborates the above definitions will be used in this thesis. "Scenario planning (SP) is a process within strategic management that combines the creation of several stories of plausible futures with the practical strategic responses that are required to deal with them. The creation of stories maps the future terrain through a systematic analysis of the key drivers of contextual change. By focusing on the uncertain outcomes

of those drivers, SP becomes a major component of organizational learning”. From the definition it can be seen that scenario planning sits well as a tool within the concept of strategic foresight.

The steps in scenario planning are Data Collection, Analysis, Synthesis, Exploration of Key Issues, Scenario Building, Scenario Writing, Scenario Testing, and Refining (McKiernan, 2017). In table 2 below, each step of scenario planning and a brief explanation of the steps are presented (Cairns and Wright, 2018, Pg 28). It should be noted that there will be some amount of circularity in the mentioned steps of scenario planning.

Table 2: Scenario plannings steps

| Stages of the Intuitive Logics scenario planning process | |
|---|---|
| Stage 1 | Setting the Agenda – defining the ‘focal issue of concern’ and setting the scenario timescale |
| Stage 2 | Determining the Driving Forces – working first individually then as a group |
| Stage 3 | Clustering the Driving Forces – group discussion to develop, test and name the clusters |
| Stage 4 | Defining the Cluster Outcomes – defining two extremes, yet highly plausible and hence, possible outcomes for each of the clusters over the scenario timescale |
| Stage 5 | Impact/Uncertainty Matrix – determining the key scenario factors, A and B |

| | |
|---------|---|
| Stage 6 | Framing the Scenarios – defining the extreme outcomes of the key factors, A1/A2 and B1/B2 |
| Stage 7 | Scoping the Scenarios – building the set of broad descriptors for 4 scenarios |
| Stage 8 | Developing the Scenarios – working in subgroups to develop scenario storylines, including key events, their chronological structure, and the who and why of what happens. |

2.3. Weak signal and scenario planning

As mentioned earlier, weak signals are an important source of raw material for strategic foresight (Mendonça, Cardoso and Caraça, 2012). “Weak signals are symptoms of possible change in the future, acting as warning sign or signs of new possibilities” (Holopainen and Toivonen, 2012, Pg 199). One of the steps in strategic foresight is scanning the environment. One of the objectives of strategic foresight is the “conscious and participatory deliberation to take advantage of fragmented, unrefined and low-quality information”. This involves the “imagining, identifying, classifying and evaluating” raw and unstructured information – Weak signals (Mendonça, Cardoso and Caraça, 2012, Pg. 219).

Thus, weak signals form an important part of any strategic foresight research/project. Scenario planning being one of the tools of strategic foresight, the initial steps is to gather driving forces of change to determine the key drivers of change. Driving forces are “the fundamental forces that bring about change or movement in the patterns and trends that we identify

as underpinning observable events in the world” (Van der Heijden *et al.*, 2002, Pg. 282). As can be seen from this definition, especially the first part – the fundamental force that brings about change, is very similar to the definition of weak signals and thus, weak signals are an important source of raw material for identifying driving forces. This thesis’ research is on weak signals within the context of scenario planning. Scenario planning is one of the tools of strategic foresight. Thus, strategic foresight and scenario planning were presented to provide the background and the context within which this research has taken place.

Chapter Conclusion

In this chapter, a brief introduction to strategic foresight and scenario planning were presented to give the background on the context for this thesis. The historical origins and how these historical origins have influenced the modern-day strategic foresight and scenario planning were also presented in this chapter. The focus of this thesis is weak signals. Thus, an in-depth systematic literature review on weak signals is presented in the next chapter. Through the literature review the research agenda and the research questions are developed and this is presented in the next chapter.

3. Systematic literature review – weak signals

In the previous chapter, strategic foresight and scenario planning were introduced. Scenario planning was presented as a tool within strategic foresight. Scenario planning invariably involves seeking weak signals of impending change as part of data gathering step. Further, as argued in the introduction chapter, it is important for organisations to recognise the subtle indications of change and respond to it in a graduated manner in order to remain competitive or relevant (Ansoff, 1975).

Considering this importance a few papers have taken stock of the literature on weak signals (For e.g., see: Holopainen and Toivonen, 2012; Rossel, 2012). Even though the present research is towards considering weak signals separately from trends, drivers etc., this was not always the case; the terms have been used interchangeably. This has led to various definitions of weak signals, albeit conveying the same meaning. But what constitutes a weak signal is ill-defined. As Bredikhin (2020, Pg 1) states “the concept as a whole remains somewhat controversial and ill-defined [and] Identification of [weak signals] remains largely qualitative and rather arbitrary process...”.

Rossel (2011) claims that Ansoff mentioned weak signals as a metaphor, and thus should not be treated more than this. Hiltunen (2008a) suggests that weak signals are a frame of mind which can be linked to the parlance of “beauty lies in the eye of the beholder”. That is, one person’s weak signal might not be another person’s weak signals. This line of thought looks at weak signal theory from the constructionist’s perspective. But there are quite a lot of research on detecting weak signals using text mining and various other technology. These papers imply a more realist stance where weak signals are out there in the environment to be found. Thus, as Rossel (2009; 2010; 2011) states, weak signals theory is lacking in the reflexive and epistemological stance.

Even though there are previous papers that have taken stock of weak signals through a literature review, these were in 2012. There are quite a lot of papers that have been published from then (for e.g., see: van Veen and Ortt (2021)). Thus, this chapter attempts to take stock of the weak signal research by conducting a systematic literature review. Apart from taking stock of the extant literature on weak signals, the research agenda for this thesis is established in this chapter. This is done by identifying the relevant gaps within each of the subsections based on the reviewed literature. Through the identified research gaps, the research questions and the research framework guiding this thesis are derived and presented.

3.1. Previous reviews on weak signals

Two papers have reviewed the literature on WS, one by Holopainen and Toivonen (2012) and the other by Rossel (2012). Paper by Holopainen and Toivonen (2012) takes stock of the WS theory from its proposal, its conceptual development, ways of detecting it, its application, and its use cases. Even though the paper by Holopainen and Toivonen gives a good picture of the concept, Rossel (2012) presents a more critical review. Taking a constructivist stance, Rossel claims that weak signal is a metaphor, an abstract phenomenon rather than theory. This critique is very important as it ignites the debate if weak signal is only based on the cognition and imagination of the observer or, in a more positivist approach, is it something that is out there regardless of the observer. Both viewpoints are supported in WS literature, and this will be presented in the later sections.

There is a common pattern of analysis in the previous reviews. The first is that weak signals are considered as the solution to dealing with, in the words of Ansoff, '*turbulent environment*', '*strategic discontinuity*' and '*strategic*

surprises'. Then the reviews move to the conceptual underpinnings and the development of the WS theory. Along with the Ansoff's WS theory (Ansoff, 1975), discussions on similar concepts in non-English speaking regions such as the French school of future studies called "La Prospective" are presented. This was presented briefly in the previous chapter. The chapter then move on the to the use of WS for a broader strategic direction, by combining WS with other tools such as 'environmental scanning', 'horizon scanning', 'strategic early warning systems', 'peripheral vision', etc.

The discussion moves on the factors affecting the detection of WS. These factors were called 'filters' by Ansoff and the main filters of WS are the surveillance filter, mentality filter, and finally the power filter.

Surveillance filter defines the field of observation. To give an example through an analogy, surveillance filter is like a pair of binoculars through which one seeks the WS. The more focused it is, the higher the chance of missing the bigger picture. The wider the focus is, then higher the chances of missing the focal issue. The challenge is to get the right balance. As Ansoff (1990, Pg 334) states "... necessary to use a technique which would capture the essential elements of that reality. The more complex the reality, the more comprehensive must be the technique". The management has a capability to observe only those issues that they have observed before. In turbulent environments, extrapolative systems filter out important discontinuity information which hampers WS detection (Ilmola and Kuusi, 2006).

Mentality filter defines the tendency of managers to be in denial or even reject novel information that does not fit into their experience or reference points. Ansoff (1990, Pg 142) states "... when the data were at substantial variance, or contrary to historical experience, they were neglected or even rejected as irrelevant".

Power filter is to do with the power dynamics of the manager. Managers tend to reject information that would potentially threaten their importance or position (Ansoff, 1990). These filters are discussed further in later section within this chapter.

Even though the two papers by Holopainen et al., and Rossel have a good literature review, these were done in 2012 which is ten years ago. And thus, the literature needs updating. This chapter aims to present a systematic literature review on WS, to take stock of the developments in WS.

This chapter is divided into the following sections. Firstly, the method for the systematic literature review along with descriptive statistics of the papers are presented. This is followed by the synthesis of the literature. The synthesis is divided into WS theory and definition, WS detection, WS application, and finally ends with a conclusion.

3.2. Literature review method

The research focus of this thesis is well established and presented in the introduction. Further, the field of weak signal research is not new and has a sizable literature with publications from the 1970s. This makes it a matured enough field to satisfy the requirements to conduct a systematic literature review. Systematic literature reviews (SLR) are considered robust and overcome the shortcomings of the traditional 'narrative' style literature reviews. The traditional reviews are often criticised for their lack of rigour, thoroughness, lack of reproducibility, and an impact of author's bias. To overcome these barriers, Tranfield, Denyer and Smart (2003), borrowing from the medical field, suggest the use of systematic literature review. The

typical steps for conducting a systematic literature review are presented in table 3 below.

Table 3: Stages of SLR

| Stages of SLR | Recommended action | Action within this thesis |
|--------------------------------|---|--|
| Stage I - Planning the review | | |
| Phase 0 | Identification of the need for a review | Reasoning given in the introduction chapter of this thesis |
| Stage II - Conducting a review | | |
| Phase 1 | Identification of research | Database search |
| Phase 2 | Study quality assessment | Quality criteria established is mentioned in the relevant subsection of this chapter |
| Phase 3 | Data synthesis | Presented as a subsection of this chapter |

This systematic literature review is based on table 3 above and by adapting from SLR in other fields of management studies. For e.g., see: Schneider and Spieth (2013); Geissdoerfer, Vladimirova and Evans (2018); Foss and Saebi (2016). Figure 2 shows the process that was followed in this paper.

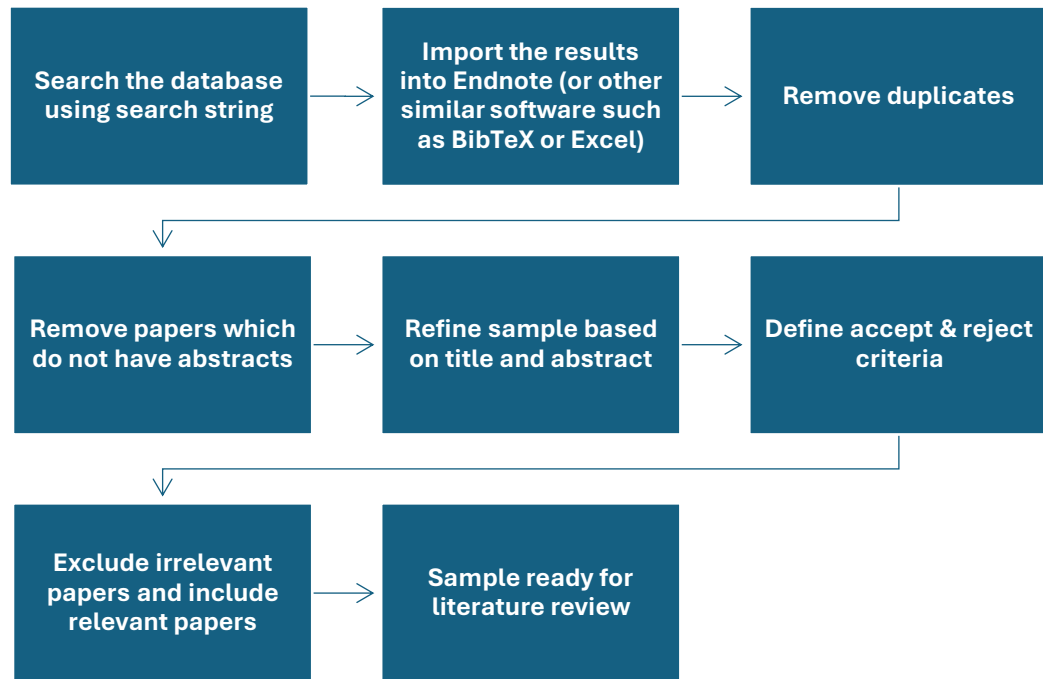


Figure 2: SLR process

Source: Author's own rendition

The well-established journal databases, Scopus and ProQuest ABI/inform (hereafter called databases), were used to search the literature. The database search for this chapter was done on 9th October 2021. Another search was done, using the same search strings as mentioned in table 4, on 13th December 2022. The only difference from the earlier search was that only papers published in 2022 were considered in the recent database search. This was done to check if any newly published papers had to be included which was not present during the time this chapter was written. There were no papers published which focused only on weak signals.

In practise, apart from the search string used for querying the database, certain exclusion criteria are put in place to avoid unmanageably large search results. The exclusions for this paper were that the papers should be in the English language within the business and management domain. All sources

were considered, such as Books, Conference Papers & Proceedings, Dissertations & Theses, Scholarly Journals etc. The only exception was book reviews. There was no time limitation that was applied.

The databases were queried using the respective search strings as shown in table 4 below. Both the databases supported truncated search function, and this was represented by '*' at the end of the keyword. The "weak sign*" search would result in all extensions of sign, e.g., signal, signs, etc. The reason for this is that many authors have used the terms, weak signal(s), seeds of change, and weak sign(s) interchangeably (Garcia-Nunes and da Silva, 2019). Thus, the '*' and including the 'seeds of change' in the search string ensured that all the usage combinations of weak signals were covered.

Table 4: Journal database search results

| Database name | Search String | Number of papers |
|----------------------|--|-------------------------|
| Scopus | TITLE-ABS-KEY ("weak sign*" OR "seeds of change") AND (LIMIT-TO (SUBJAREA , "BUSI")) AND (LIMIT-TO (LANGUAGE , "English")) | 284 |
| ProQuest ABI/inform | ti("weak sign*" OR "seeds of change") OR ab("weak sign*" OR "seeds of change") | 244 |

The search result for Scopus was 284 papers and for ProQuest ABI/inform was 244, taking the total to 528. The collection of documents shall be referred to as corpus from hereon. The search results from the databases were imported to EndNote software (X9 desktop version).

Endnote was able to eliminate the duplicates automatically, but some of the duplicates had to be eliminated manually. EndNote considered these papers different since these papers had minuscule differences such as, one paper had a punctuation mark that the other paper did not have. The total duplicates that were eliminated from the corpus was 125 papers. Another 13 papers were removed as they were book reviews and did not have abstracts. Wherever possible, all attempts were made to locate the abstract and papers. Only those papers that could not be located were dropped.

The corpus was now ready for title and abstract based reviewing and the length of the corpus was 385. For conducting the review based on the title and abstract, the following inclusion criteria was decided.

- The papers had to be based on OR further build upon the concept of weak signals as described by Ansoff.
- The papers had to be informed by research and should not be an opinion piece by practitioners.
- The paper should be free of grammatical errors and should be in good quality English.
- Papers that merely mention that WS should be detected without delving further were rejected.
- Papers focusing on foresight or other environmental scanning methods, but which mentioned WS as only a step without delving

deeper were also rejected. This was done as the focus of this literature review is to contribute to the knowledge base of weak signal and not to the knowledge base of foresight or environmental scanning methods.

Table 5: Papers count stage wise

| | |
|--|------------|
| Combined papers from Scopus and ProQuest ABI/inform | 528 |
| Remove duplicates | -125 |
| Remove papers where abstracts are missing and if papers are book reviews | -13 |
| Remove papers with no access or if paper is non traceable | -5 |
| Total for reviewing title and abstracts | 385 |
| Remove papers not relevant and not within the accept/reject criterion | -221 |
| Final Total for study | 164 |
| Further rejection after reading full paper | -61 |
| Manually added papers | 3 |
| Final corpus – I | 106 |

A total of 221 papers were removed because it did not meet the accept/reject criteria or if the paper was not in the related field. For e.g., *"Antenna array super-resolution method for moving signals"* and *"Approach to weak signal detection via over-sampling and bidirectional saw-tooth shaped function in wearable devices"* were rejected as these papers were from non-related fields. The total papers left for full reading was 164. A further of 61 papers were rejected after reading the full papers as they were deemed not to meet the criteria. Whilst reading full papers, it was deemed necessary that 3 papers needed to be added manually to the

corpus. The final corpus for the SLR was 106 papers. Table 5 shows the step wise number of eliminated papers.

Due to progress of time, another search was conducted on 28th of May 2024 using the same search strings as before. The same two database used in the earlier search were used – Scopus and ABI/Inform Proquest. Table 6 below shows the results from the research along with the search string for the respective database.

Table 6: Updated database search results

| Database | Search string | No. of results |
|----------------------|--|-----------------------|
| Scopus | TITLE-ABS-KEY ("weak sign*" OR "seeds of change") AND (LIMIT-TO (SUBJAREA , "BUSI")) AND (LIMIT-TO (LANGUAGE , "English")) | 323 |
| Abi/inform proquest: | ti("weak sign*" OR "seeds of change") OR ab("weak sign*" OR "seeds of change") | 439 |

The total papers from the search resulted in 762 papers. This included duplicates. To eliminate duplicates, the result was imported to EndNote software. As the software had the capability to remove duplicates automatically. All papers before 2022 were deleted as these papers were included in the pool of papers from the earlier search. A total of 654 papers were deleted. The remaining 19 papers were taken up for accept or reject based on title and abstract. Table 7 below shows paper count in stages for the search in 2024.

Table 7: New search step wise paper count

| | |
|---|------------|
| Combined papers from Scopus and ProQuest ABI/inform | 762 |
| Remove duplicates | -89 |
| Papers deleted prior to 2022 | -654 |
| Total for reviewing title and abstracts | 19 |
| Remove papers not relevant and not within the accept/reject criterion | -7 |
| Final Total for study | 12 |
| Further rejection after reading full paper | -3 |
| Manually added papers | 1 |
| Final corpus – II | 10 |

Thus, the final total of the final corpus for review was 116 (106 from the first search and 10 from the recent search).

The final corpus was imported to an MS-Excel (henceforth referred to as just excel) to create a database. The following information were imported – title of the paper, abstract, author names, author affiliation, paper type, published year, and journal name. Further, the following fields were added as column names in the database and populated as and when a paper was reviewed: Country, Country 2, Paper type (empirical or conceptual), Method, WS theory / concept, WS detection, WS detection issues, WS classification, WS processing / sense making, Overcoming issues with detection, WS application, and WS as part of framework.

Before moving on to the next section where the literature is synthesised, various descriptive statistics of papers is presented below. To enable plotting the descriptive statistics, whenever a paper was taken up for study, the paper type, that is if the paper was empirical or conceptual was noted in the

relevant field as mentioned above. If empirical, then depending on the method used the paper was classified as qualitative, quantitative, mixed, or as multi method. The author's country of affiliation was also noted. Finally, depending on the content, the papers were classified but updating the relevant column: WS theory, overcoming issues with detection, WS as part of framework, WS classification, WS application, WS detection, WS detection issues, or WS processing / sense making. It should be noted that many papers belonged to more than one category.

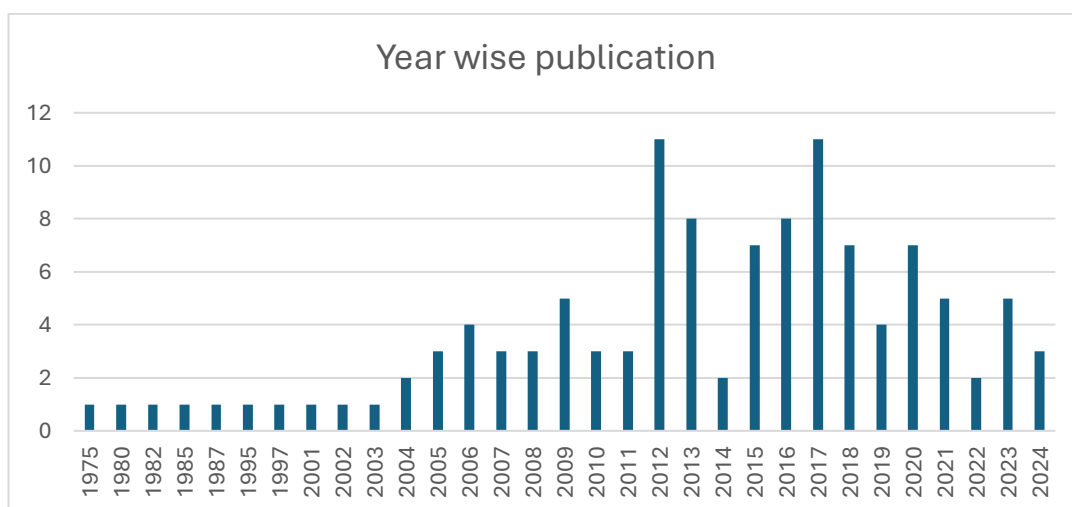


Figure 3: Year wise publication

Figure 3 above shows the year wise publication of papers. It can be inferred from the table that the number of papers published started growing from the late 2000s. This could be because of the increase in turbulent business environment due to technological disruptions that started from the internet boom.

Looking at the authors country of affiliation, authors from Finland seem to be the top contributors. This was followed by Germany and UK. The remaining countries were mainly from Europe, Russia, and the USA. The reason for this low uptake in other countries is unknown and could be a research agenda for

future researchers. Figure 4 below shows the distribution of the contribution by country.

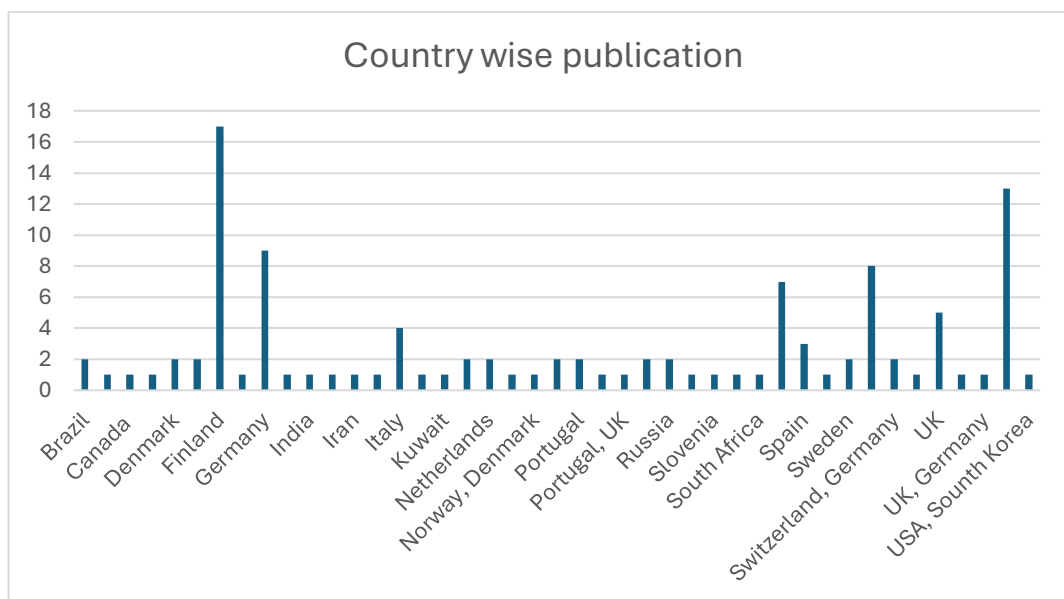


Figure 4: Country wise publication

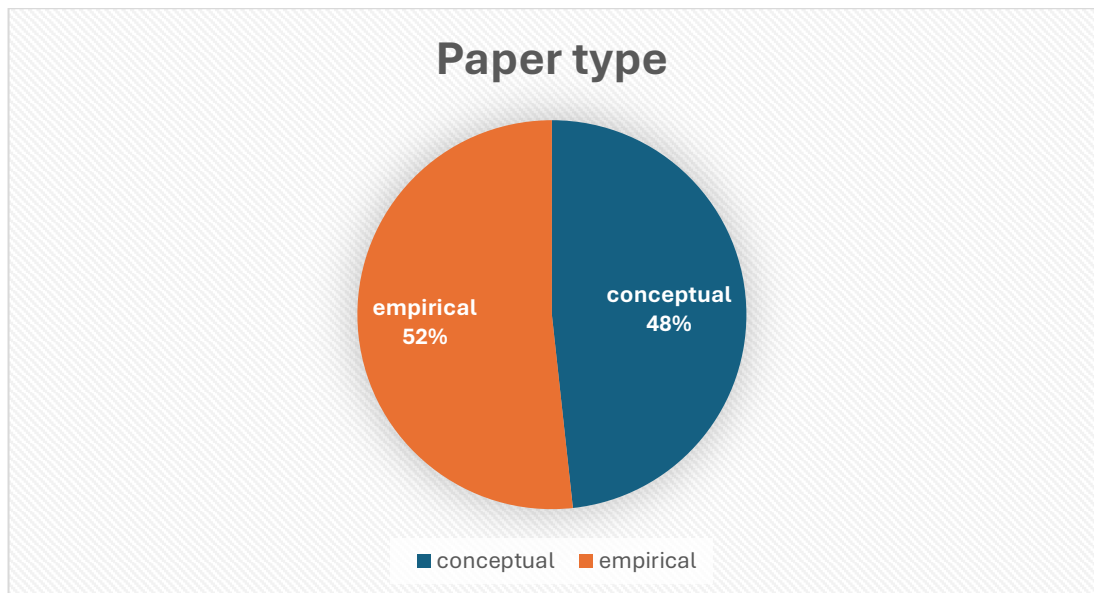


Figure 5: Paper type

It was found that the literature was balanced with respect to empirical and conceptual papers as seen in the above figure 5.

Figure 6 below shows the distribution of papers based on the research method. There was a good balance of both quantitative and qualitative methods. With quantitative methods slightly more than qualitative methods. There were some mixed methods papers as well, which was expected given the nature of WS theory.

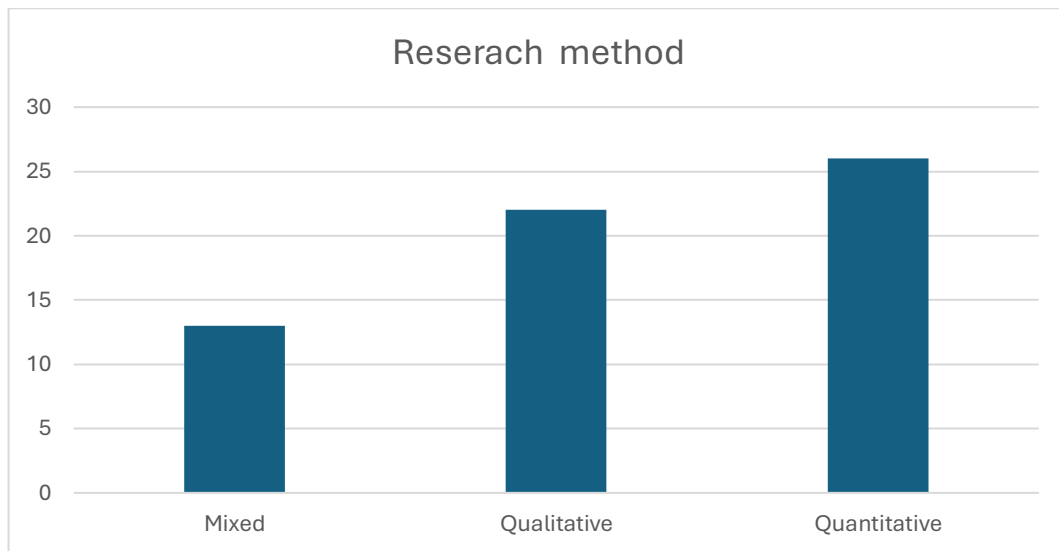


Figure 6: Research method of literature

Figure 7 below, shows the trend of choices of research methods in the literature through the years. The year of publication have been binned which can be on the x-axis of the graph. With respect to the methods mentioned above, qualitative papers dominated till early 2000s. However, from 2020 onwards, a shift towards quantitative methods can be seen. This could be due to the focus on AI and machine learning based methods. Nonetheless, there are some qualitative research papers. Overall, there is a sudden rise in papers being published from 2005 onwards. This could perhaps be the economic downtrends such as the global financial crisis, etc.

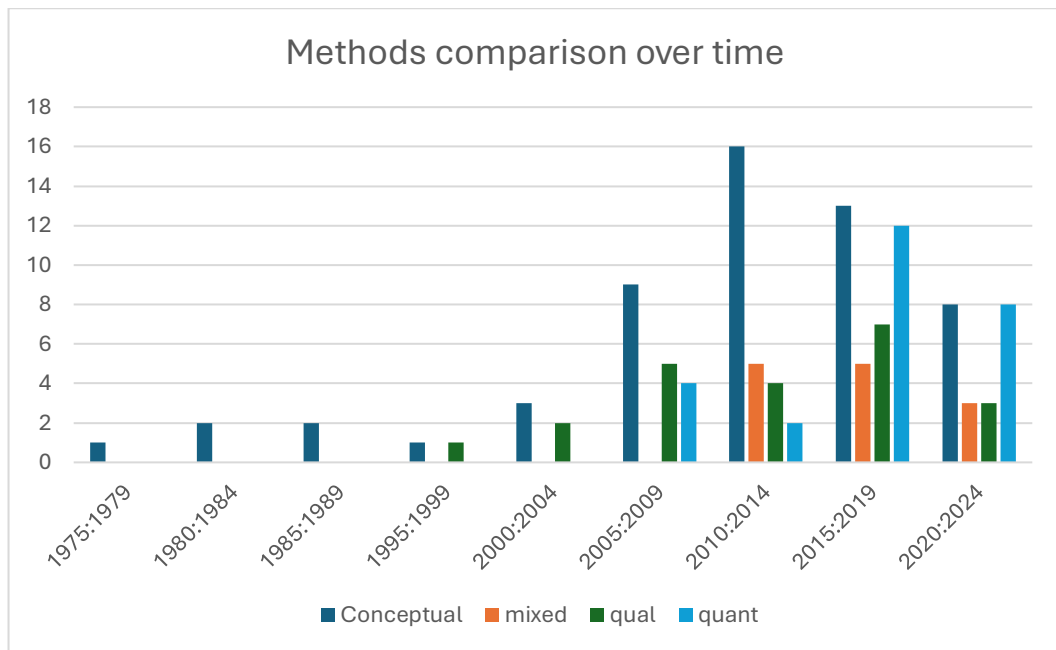


Figure 7: Literature research methods trends timeline

With respect to the classification, the papers were classified as following: WS theory, overcoming issues with detection, WS as part of framework, WS classification, WS application, WS detection, WS detection issues, or WS processing / sense making the categories mentioned earlier, as seen in figure 8 below. Majority of the papers mainly discussed about WS detection and WS theory. The next main category was WS as part of a framework such as horizon scanning or early warning systems. It should be noted that many papers had more than one category and thus papers would be counted in multiple categories.

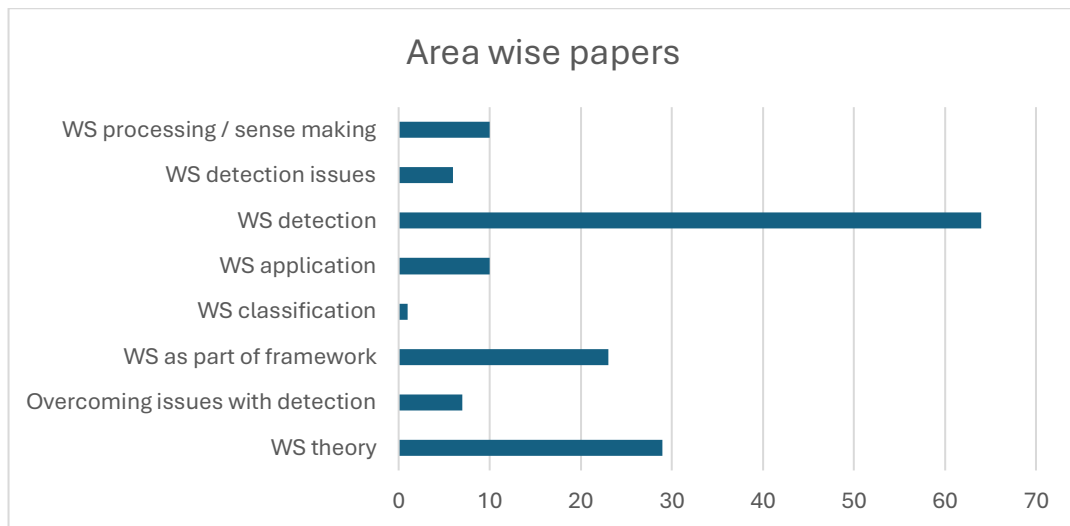


Figure 8: Weak signals area wise

From the above descriptive statistics, some interesting questions arise such as why do authors from Finland have the maximum contribution? Why do other countries lag in contribution? Why has the number of publications increased in early 2000s – was it due to the global financial crisis, or due to advancement in technology, or was it due to the dotcom bubble burst? Why has there been an increase in quantitative papers from 2020s? Is it due to the focus on AI? These questions can be taken up as future research avenues by researchers.

Having presented the brief outlook of the corpus, the synthesis of all the papers is presented in the following sections. The synthesis is divided into WS theory and definitions, WS detection, WS analysis, WS application, and conclusion and limitations. In each category various arguments are presented, and research gaps are identified.

3.3. Weak Signals theory and definitions

The WS theory was first proposed by Ansoff (1975) in his seminal paper, “Managing strategic surprise by responding to weak signals”. Ansoff states “A

weak signal is an early indication of a change whose impact is expected to be very significant, but the mechanism of impact cannot be described accurately enough to permit management to devise a specific "strong" response, or to compute the size of an impact" (Ansoff, Kirsch and Roventa, 1982, Pg 240)

Many authors have adapted and developed this definition further. Godet defines weak signal as ambiguous, seemingly unimportant or unexceptional trend that can considerably impact an organisation's aims and objectives but requires correct interpretation (Godet in Rowe, Wright and Derbyshire, 2017). Kuosa (2011a) defines weak signal as an anomaly in the known transformation. José Poças (2018) defines WS as perceptions of possible changes, essentially hypothetical, within a process of construction of socially relevant knowledge. And Mendonca et al. (2004);(2012) define WS are perceived symptoms of change.

Ansoff proposes that a response is needed based on the WS detected to remain competitive. The response is based on the strength of the signal and the threat/opportunity (T/O) it (WS) is offering. If the signal is weak then he suggests that the WS should be monitored. And as the intensity of the signal increases, he suggests, the organisation's response should be swift too.

The multiple definitions and the mention of strength bring out a critical debate about the WS theory; are weak signals independent of the person looking for it? As in some definition the word "perceived" is used. But other definitions imply that WS are independent of the observer. Most of the WS literature does not explicitly address this issue but a few of them that do, take a constructivist stance. For e.g., Mendonça, Cardoso and Caraça (2012, Pg 221) states "... we underline the inescapable situatedness of weak signals, i.e. they lie in the ears of the listener". Rossel (2010) is of the similar constructivist view and goes further to say that WS is just a metaphor by

stating “‘Weak signal’, a metaphor to tackle the need to be ‘early’ regarding changes and uncertainties” (Rossel, 2009).

This line of argument also leads to the “strength” of the WS as mentioned by Ansoff. Referring to Ansoff, José Poças (2018) suggest that strength of the signal implies a sense of distance from an event that is being signalled. And that a weak signal transforms into a strong signal and the signal transforms into a trend. This suggests a sort of distance and a possibility of measuring weak and strong signal. But such a measurement is not possible as, Ansoff himself states, “Soft facts are typically qualitative, often ambiguous, and express the personal views and opinions of individuals who are frequently unable to provide a logical support for their positions” (Ansoff, Kirsch and Roventa, 1982, Pg 240). Also, as Rossel states “There is almost certainly no way to ‘know’ the future, in the sense of ‘knowing exactly’. However, as a matter of survival, human beings have devised several means for partially dealing with this problem” (Rossel, 2011, Pg 1).

Based on the above reasoning, the strength of the signal is dependent on the interpreter and thus, so does the response (Jørgensen, 2012). With respect to strength of the signal, Cevolini (2016) concludes in effect that there cannot be a distinction between strong and weak signals. He states that “...the outcome is that in social systems any signal is actually weak, never strong, and this very fact somehow jeopardizes the validity of the difference between weak and strong” Cevolini (2016, Pg 11). Bringing in the above aspect of interpreter, Hiltunen (2008a) introduces the term ‘sign’ instead of signals in weak signals. She states that “weak signs are signs which may foretell future events” Hiltunen (2008a, Pg. 249). She bases this on the Peirce’s triadic model (Atkin, 2022) and says that there are three aspects of a sign, the signal, the issue, and the interpretation. She uses the word sign, instead of the word signal, to bring in more clarity to the term WS. As signals can have an unintended interpretation from the lens of

physical sciences. As a signal in the realm of physical sciences has a different meaning than that within the futures studies (Carbonell, Sánchez-Esguevillas and Carro, 2015). But one difference she brings to the WS argument is from a philosophical standpoint. She states that she is taking a realist stance, but she falls short of justifying this apart from stating that it is her choice.

To unify this divide, van Veen and Ortt (2021, Pg 11) have done an extensive literature review. Using keyword pairing and analysis they have come up with the following definition on weak signal, "A perception of strategic phenomena detected in the environment or created during interpretation that are distant to the perceiver's frame of reference". This definition addresses the previous ambiguity of the observer/perceiver and implies that WS are indeed influenced by the observer's frame of mind. A common saying in the English language can be adapted to this situation to convey the idea – one man's weak signal is another man's noise. Ahlqvist and Uotila (2020) make two additions to the perceiver's weak signal argument – the personality and the context. These two aspects are under-researched in the field of WS theory.

The author takes a pragmatist stance that the context is of importance. Pragmatism is of the stance that reality is too dynamic and therefore it is futile to attempt to discover it. And as, Rorty states "the pragmatists criterion for knowledge is practical utility rather than ontological reality" (Rorty, 1998 in Johnson, 2007). Thus, the focus should primarily be on WS detection & analysis and not on the strength as the priority is to stay in competition. Even though WS are indeed the perspective of the perceiver, nonetheless, at times there are some obvious signals of impending change which are universal. For e.g., Signals before the Iraqi invasion of Kuwait or, more recently, the signals before the economic crisis caused in 2008 due to the housing bubble.

To generalise further, this research takes a stand that rather than placing emphasis on the observer, the focus should be on the situation or circumstances. For instance, if weak signals are sought as part of national foresight programme such as UK horizon scanning programme called the sigma scan and the delta scan (Miles and Saritas, 2012), the signals can be classified in terms of weak and strong based on factors such as the PESTLE (or similar) frameworks. But if the WS is being scanned in an organisation specific context, such as competition analysis, then the WS would be subjective to the observer.

Even with these arguments attempting to clarify the concept and theory of WS, it is yet ill-defined and it is a very subjective process. This is hampering the perceived benefits that WS theory could bring to an organisation and in turn this would hamper the growth of the theory. As Schwarz (2009b, Pg 87) mentions about the reactions of many managers when asked about WS and foresight – “We don’t work with scenarios or trends because they are never right”. This thinking will not change unless clarity of the concept and its benefits are shown.

An important question asked by Rossel (2011, Pg 380) is “How do we know weak signals are weak signals, and which of them are more or less certain (or uncertain), relevant or irrelevant, impactful or impact less, subjective or objective?”. There is no research where the validity of the weak signal theory has been verified, apart for some illustrative use cases. Even though this statement seems to have a positivist tone, what is being said is that there is no empirical research, such as a longitudinal study, that have been carried out to investigate the claim of weak signal detection, action taken upon the detection of weak signal, and the claim of benefit that this detection and action would bring. As Rossel (2011, Pg 376) states, “This blurred use of early detection concepts is not surprising; after all, they are only metaphors; their added value lies in their effectiveness and the results they can help

trigger". The last bit of Rossel's statement is important, as firstly the effectiveness of weak signal is unknown and thus, it is difficult to argue against claims on the validity of WS such as "it's only a metaphor".

The presumption that the coming changes are all comprehensible is another limitation of weak signal theory. Not all changes are understandable due to the limitation of a person's ability to comprehend. For e.g., the advent of PCs could not be estimated by IBM (Broadbent, 2005). This can be addressed by modes of reasoning - anticipating critique and occasional reasoning. But the empirical evidence as well as the practice of its use in organisation is missing (Seidl and Van Aaken, 2009).

Another drawback that needs to be addressed with respect to WS is the argument that it is always easy to retrospectively spot weak signals of an event that has already occurred. This is important as most of the empirical papers on WS detection use illustrative case studies where the outcome is already known. Roux-Dufort (2016, Pg 29) state that "It is always easier to attribute warning signs to an event when the final outcome is known or expected". He further states that "This [weak signals theory] leaves a lasting impression that crises never happen by chance, and that we might have or should have seen it coming. All too often these reconstructions imply a culpable ignorance on the part of those who knew or could have known and did or said nothing. When the final result is known, advance clues are combined in a biased and often accusatory way". This is an important criticism of WS theory that needs to be addressed through debates and empirical research.

The above line of thought is similar to the arguments made by Horton (2012) and Poli (2012). Using complexity science, they argue that an organisation is part of a complex system and due to this complexity, it is not possible to pinpoint a trigger (weak signal) before a turbulence. Even if there exists such

a weak signal then these signals would be part of a trend, which in turn would be part of the system, else the WS would be stateless (Poli, 2012). Horton (2012, Pg 294) who states that "Complexity science demonstrates that disruptive events do not need an associated trigger, as they are a normal part of a complex system. This insight implies that if we are always looking for weak signals we will certainly be caught unawares". Essentially saying that only a reactive stance, rather than proactive stance, can be taken by an organisation. Derbyshire (2016) using the 'butterfly effect' metaphor of complexity science, suggests that the system is far too complex to identify the cause and effect. But he goes on to say that, nonetheless it is worth exploring WS as events are also influenced by factors such as 'feedback' and 'attractor states'. And because of these factors, the WS might have multiple outcomes but is not as chaotic as 'butterfly effect'.

Bredikhin, taking the complexity based view, defines WS as "... an early perceptible pattern that reflects instability in a particular (natural, social, economic, organisational, etc.) complex portion of reality and announces the existence of qualitatively different alternative states of this portion" (Bredikhin, 2020, Pg 8). This definition now blurs the difference between trend and weak signal which is claimed to be different by many authors. For e.g., see (Saritas and Smith, 2011).

Considering these distinct and opposing arguments on WS has led Bredikhin (2020, Pg 1) to make a very strong claim that "the concept [of weak signals] as a whole remains somewhat controversial and ill-defined. Identification of [weak signals] remains largely qualitative and rather arbitrary process".

Research Gap: There is a need for debates on the philosophical points of view on WS for addressing the shortcomings in its definitions. Empirical research is needed to establish the benefits accrued by organisations which have sought WS.

In the next section, the weak signal detection methods, and the obstacles in detecting weak signals will be discussed.

3.4. Weak Signal detection

According to Ansoff, the first step to manage turbulence in a business environment is by detecting weak signals of impending change. But based on the arguments from the previous section, it can be seen that there are some issues with the WS theory itself. Logic would dictate that this needs to be attended to before making claims on WS detection and the methods for detection. Nonetheless, as pointed out before, there seems to be a consensus that an organisation can be resilient by early detection. But the need for clarity on WS theory definitely has an effect on WS detection. So much so that Rossel (2011, Pg 379) states "In fact, only a few authors bother to give any clues on how to actually find them".

At the first instance, it would be easy to reject this statement by giving examples from empirical studies that have been published. But at the same time, even though these papers claim that they have detected weak signals, they are mostly based on illustrative and retrospective case studies. And thus, in most of these cases, the event has already occurred, and the outcome known. Also, the papers fall short to mention how their method affected the strategic direction of the organisation and if indeed the organisation benefitted from it. This throws an important question about the effectiveness of the methods proposed for detection of weak signal. This section will discuss on the various methods that have been proposed in the literature. The papers that discuss on WS detection, either present their paper only based on the WS theory or as part of a foresight tool such as environmental scanning system or horizon scanning etc.

Considering the advancements in technology and social media, especially big data, the recent papers place emphasis on using the internet and online content for WS detection (Decker, Wagner and Scholz, 2005; Laurell and Sandström, 2022). The overarching methods that advocate the use of technology are based on text mining and social media analysis with papers suggesting variations of these methods. Table 8 shows a representation of the papers and their respective variations of technology-based approaches.

Table 8: Technology approaches in literature

| Authors | Method | Data type / source |
|--|----------------------------------|--|
| Glassey (2009; 2012) | Folksonomies | Start-up map |
| Pang (2010) | Web scraping / social scanning | Online social websites, twitter, blogs, etc. |
| Thorleuchter and Van den Poel (2013); Thorleuchter and Van den Poel (2015) | Web mining | Keyword based internet crawling |
| El Akrouchi et al. (2015) | Text mining | Various internet sources |
| El Akrouchi, Benbrahim and Kassou (2021) | LDA | |
| Yoon (2012) | Text mining | Web news |
| Lee and Park (2018) | Text mining | EBSCO host database |
| Yoo and Won (2018) | Agent based simulation (NetLogo) | Various online media |
| Vicente Gomila and Palop Marro (2013) | Tech mining | ISI WoS database |

| | | |
|---------------------------------------|--|--|
| Park, Cho and Heo (2021) | Keyword & document similarity | Journal abstracts |
| Kim and Lee (2017) | Key word rarity | Futuristic data – future oriented opinions from online communities |
| Kim, Park and Lee (2016) | Key word analysis | Futuristic data – future oriented opinions from online communities |
| (Sjöblom et al., 2013) | Data mining and Clustering analysis | Aviation and health datasets |
| Bisson and Diner (2017) | Graph theoretical approach | Survey and expert opinion |
| Kwon et al. (2018) | Keyword network analysis | ORBIS database |
| Song, Elvers and Leker (2017) | Patent convergence | International Patent Classification data |
| Zhao et al. (2024) | Statistical | Primary data collection |
| Bzhalava, Kaivo-oja and Hassan (2024) | NLP, keywords, co-word analysis, correlation explanation (COREX) topic modelling | Crunchbase database |
| Ma, Mao and Li (2024) | Keyword and citation network analysis; Statistical | Academic papers |
| Xie, Ma and Li (2023) | NLP, outlier analysis, LDA for convergence and monitoring | Academic papers |
| Ha, Yang and Hong (2023) | NLP, keyword extraction, Graph | Academic papers |

| | | |
|----------------------------------|--|----------------------|
| | convolutional network (AI) | |
| Cheng and Sul (2023) | Semantic network analysis | Chinese social media |
| Ebadi, Auger and Gauthier (2022) | Keyword extraction, deep learning, and expert validation | Academic papers |

From the above table, the text mining process followed by the papers can be generalised as:

Deciding the source of the data → Mining the data (various methods) → analysing the data (various methods) → Classifying the data (as weak signals).

An in-depth discussion and explanation of the previously mentioned technological methods are beyond the scope of this research. But for a much deeper discussion from a method point of view, refer: Mühlroth and Grottke (2018). Through an SLR, they take stock of various methods for detecting WS and trends for strategic foresight using technologies such as data mining, machine learning, artificial intelligence etc. They conclude that even though there is a good amount of research on using technology within WS, there is a further scope to introduce automation to reduce human interference and bias.

Moving slightly away from just keyword based analysis, Garcia-Nunes and da Silva (2019; 2020) suggest the use of sentences from the content of the web crawler to put it to test as suggested by Hiltunen (2008a) for the confirmation of WS. Similarly, Garcia, Noya and Gurzawska (2020) combine the use of an AI based system and crowd/expert perception for WS detection

and analysis. Thus, these paper moves from depending wholly on technology to a hybrid method of using machine to aid human classification. Kim et al. (2013) take a similar mixed method approach and introduce the NEST framework developed by the Korea Institute of Science and Technology Information for the detection of WS of emerging trends. The source for the detection of WS is from information fed through a global network of experts. The quantitative part of the framework uses clustering, pattern recognition, and cross-impact analysis using a Bayesian network. And the qualitative part uses techniques such as environmental scanning, brainstorming, and Delphi study.

Taking a mixed methods approach as Kim et al. (2013) but moving away from text mining and technology to a quantitative approach, Carbonell, Sánchez-Esguevillas and Carro (2015) use the causal layered analysis (CLA) for the detection of WS. CLA uses four layers of analysis using both qualitative and quantitative methods. The paper then uses the Ansoff (1990) model for classification of WS. Mohammadi, Mohammad Rahim and Sajjadi (2017) analyse wild cards as a source for WS and use fuzzy TOPSIS, a prioritisation method, to prioritise WS for further action. Hoisl, Stelzer and Biala (2015) move away from the use of technology and instead use conjoint analysis with internal and external expert for detecting WS on technological discontinuity.

But the problem with the above papers that explore the technology based WS detection methods is that the papers are based on illustrative case studies. That is the papers look at a problem/data retrospectively. As mentioned earlier, it is always easy to retrospectively spot a weak signal and at times it is influenced by the 'availability heuristic' or "I knew it all along phenomenon" (Inman, 2018). Thus, the ability of the technology-based method to detect the actual weak signals of impending change is unknown. The other issue is the implicit assumption in these papers that these

technologies can indeed detect WS. This implicit claim has not been subjected to empirical research. Further, the papers also take an implicit realist stance that weak signals are something that exist in the environment awaiting to be found. Which, as discussed earlier, is not as simple as it seems.

Research Gap: Empirical research and validation are required for the quality and quantity of weak signals detected by technology-enabled methods such as text mining and machine learning. Especially using case studies in the present timeline rather than illustrative and retrospective case studies of events which have occurred in the past.

Departing from the technological oriented WS detection methods, Schwarz, Kroehl and von der Gracht (2014) and Schwarz (2015) propose a very unique source for WS detection. They suggest the use of novels, science fiction prototyping for detecting WS. They also suggest that this would increase the creativity in managers to process WS. In a more traditional way and as an experiment on the influence of WS, Takala and Heino (2017) manually scan newspapers and blog texts to analyse for WS for a particular industry – water sanitation. Similarly Pitkänen and Vepsäläinen (2008), through qualitative analysis, analyse media (electronic newspapers versions) and policy documents for detecting WS.

Saritas and Smith (2011) suggest futures expert as source for detecting WS. They conduct a survey of futures experts from FTA (Future-oriented Technology Analysis) Conference, 2008, to understand the overall outlook of the future. Similarly based on a survey Hiltunen (2008b) come up with an extensive list of good sources for WS. The sources are based loosely on the PESTLE ¹ framework. Rowe, Wright and Derbyshire (2017) use the

¹ PESTLE = Political, Economic, Social, Technological, Legal, and Environmental factors

backwards logic method of scenario development to identify WS. Meissner, Brands and Wulf (2017) suggest the use of both internal as well as external experts for WS scanning and introduce the 360° Stakeholder Feedback framework. In a modified version of Meissner, Brands and Wulf (2017), Mayer et al. (2013) propose the 360° environmental scanning system using information systems for WS detection. Similar to Meissner et al., Kuosa (2010) suggests the use of both environmental scanning and pattern management to detect WS. The basis of this is that a grand transformation can occur in many different ways.

Some of the other methods for detecting WS are by analysing the 'discarded seeds of change' (Warnke and Schirrmeister, 2016), desk research and expert opinion (Saritas and Proskuryakova, 2017), the use of extreme views presented in Delphi study (Markmann, Darkow and von der Gracht, 2013), thematic qualitative analysis of case interviews (Flick et al., 2020), projects, social media (Cachia, Compañó and Da Costa, 2007), business wargaming (Schwarz, 2009a) etc.

Even though there are quite some papers on methods for detecting weak signals, most of them are stand-alone papers on the method. Thus, there is a need for subjecting each of these methods empirically to more varied data and contexts for enhancing the knowledge base as well as for the progression of the weak signal theory.

Research Gap: WS detection need to be subjected to more and varied empirical research.

Having presented the various methods of detecting WS, in the next section the discussion surrounding challenges to the analysis of WS will be presented.

3.5. Weak Signals analysis

Ansoff (1990) proposed that weak signals need to travel through three filters before they become meaningful. The three filters are surveillance filters, mentality filters, and power filters. The filters were defined and presented in the earlier section of this chapter. This flow of information through the filters is represented in figure (I).

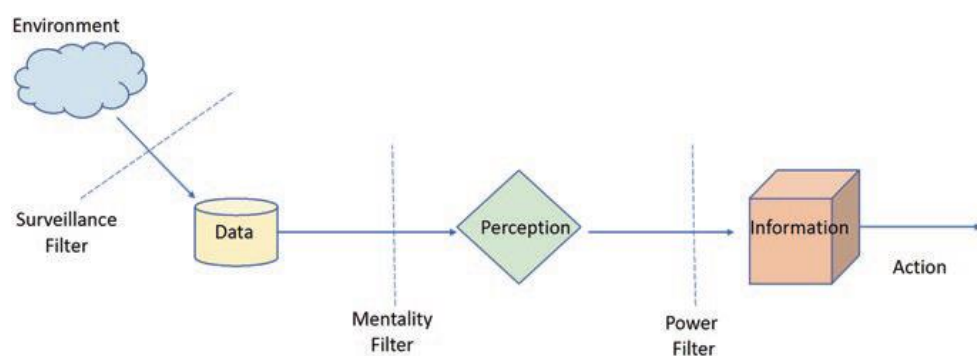


Figure 9 Filters of weak signals
Source: (Ansoff, 1990)

It should be noted here that, though the figure 9 above depicts a linear process, it isn't. The filters are similar to the common biases that affect the foresight tools such as Availability heuristic, Framing, Hindsight, Confirmation bias, Overconfidence, etc (Barnes JR., 1984;Keh, Der Foo and Lim, 2002;Ehrlinger, Readinger and Kim, 2016;Costa et al., 2017;Acciarini, Brunetta and Boccardelli, 2021). Availability heuristics is the tendency of people to place emphasis on an event's occurrence based on the ease at which it comes to mind. Hindsight is the tendency of people to overestimate an outcome by placing emphasis on one factor which appears to have influenced the outcome – commonly referred to "I knew it all along phenomenon" (Inman, 2018). Confirmation bias is when people seek information which satisfies their belief and ignore any inconsistent

information (Casad, 2022). Framing is the tendency of people to evaluate an event depending on how the event is described (positive or negative). Overconfidence is the tendency of an individual to overestimate or over-perceive their ability than it is in real.

From the papers published by Ansoff, for e.g.: Ansoff (1980) and from the book (Ansoff, 1990) by him, it can be deduced that Ansoff generalised these biases mentioned earlier into different filters – Surveillance, Mentality, and Power. The exact reason as to why Ansoff chose the filter approach rather than more specific biases-based approach as factors affecting the processing of weak signals is unknown.

Clearly, these filters play an important role in the detection and processing of WS. For e.g., as Oikarinen, Salminen and Mäkimattila (2012, Pg 516) state “It was challenging for SMEs to perceive new signals which do not fit their current operations or existing knowledge structures. The deviating signals were easily judged, without deeper investigation, as not relevant”. But the research on these filters is very sparse. The research is so sparse that Rouibah and Ould-Ali (2002, Pg 137) state that “Interpreting weak signs is a real problem encountered by many managers in different organisations that is closely related to the strategic decision-making process. This process is recognised as ill-structured and not adequately understood”.

A few papers have researched directly on the filters; Ilmola and Kuusi (2006) base their research on overcoming the filters by introducing the concept of depth and width of the filter. Ilmola and Kuusi (2006, Pg 918) state that “a deep, narrow filter produces a well-focused, very predictable one-scope aggregate level output. A flat and wide filter produces a wide diversity of concrete issues emerging from many different source”. Also, one of their propositions was that a multistep process increases the depth of the filter which is not desirable for detecting WS.

By citing various historical events Schoemaker and Day (2009) and Roberto, Bohmer and Edmondson (2006) suggest that biases should be proactively sought and recognised so as to overcome the effects of the biases. Examples of some of the biases they state are wishful thinking, egocentrism, group thinking, selective memory, etc. Milovidov (2018) suggests three biases, as against filters, that will impede WS detection. The biases are the symmetry of delusions, aggressive neglect, and the curse of knowledge. Table 9 below shows the above-mentioned biases and its definition. Similar to Schoemaker and Day (2009) and Roberto, Bohmer and Edmondson (2006), Milovidov (2018) suggests that these biases should be actively sought, recognised, and overcome to reduce the effects of the biases. Another method, apart from the ones mentioned earlier, for overcoming the biases is by MacKay and McKiernan (2006). They suggest the use of casual field and counterfactual reasoning to overcome the biases. Counterfactual reasoning "is a pervasive element in people's socio-cognitive functioning. It involves imagining alternative versions of past events or simply put, asking "what ifs" about the past. Evidence has shown that when events violate one's expectations (i.e., abnormal events), a cognitive search for explanations is trigger" (MacKay and McKiernan, 2006, Pg 100).

Table 9: Biases definition

| Bias | Definition |
|-----------------------|--|
| Symmetry of Delusions | "A state of persistent false confidence evenly distributed throughout society or within certain social groups, the symmetry of delusions is quite hard to identify at a given moment in time as proving that specific opinions are wrong is difficult. Mass consciousness rejects the disproof of commonplace views and social expectations. The symmetry of |

delusions in most cases can only be revealed post factum” (Milovidov, 2018, Pg 94).

| | |
|--------------------|--|
| Aggressive Neglect | Aggressive neglect of information, facts, or phenomena is expressed as individuals’ conscious refusal to accept something that does not match their views or understanding (Milovidov, 2018, Pg 94). |
| Curse of Knowledge | The term ‘curse of knowledge’ comprises overconfidence and overestimating one’s own abilities, leading people to rely on their knowledge and experience so much that they cannot imagine possibly being wrong while exaggerating the probability of others’ making a mistake (Milovidov, 2018, Pg 94). |
| Rationalisation | Interpreting evidence in a way that sustains a desired belief (Schoemaker and Day, 2009, Pg. 83). |
| Wishful thinking | Wishful thinking leads us to see the world only in a pleasing way, denying subtle evidence that a child is abusing drugs, or a spouse is being unfaithful (Schoemaker and Day, 2009, Pg. 83). |
| Egocentrism | Overemphasizing one’s own role in the events we seek to explain (Schoemaker and Day, 2009, Pg. 83). |

| | |
|----------------|---|
| Group thinking | Group thinking can fall victim to narrow-minded analysis, tunnel vision, a false sense of consensus and poor information gathering, resulting in groupthink (Schoemaker and Day, 2009, Pg. 83). |
|----------------|---|

But even with a few papers touching the topic of filters (and biases), there is a need for empirical research on how these filters affect WS and on how managers overcome these filters. One paper by van Veen, Ortt and Badke-Schaub (2019) does this. They research on 'high performance managers' to understand how these managers overcome these filters. They state that managers compensate for filters of WS by deliberately exposing themselves to information that does not fit their mental model. And the managers included as much information as possible to overcome the surveillance filter.

Making sense of weak signals or analysis is particularly under researched. Recently, two papers emphasise the importance of sensing and amplifying weak signals (Pinsonneault and Choi, 2022; Shankar, Bettenmann and Giones, 2023). Though, they make compelling arguments, they fall short on filters that affect the sensing and amplifying of weak signals. Similarly a book by Gomez and Lambertz (2023) comprehensively discuss about weak signals from sensing (along with various tools to detect) to acting on weak signals. Nonetheless, they seem weak with respect to empirical research and with respect to sensemaking with a lens of filters of weak signals.

The book by Weick (1995) on sensemaking has immense application to WS theory. As Ancona (2012, Pg 03) states, "Sensemaking involves coming up with a plausible understanding – a map – of a shifting world; testing this map with others through data collection, action, and conversation; and then refining, or abandoning, the map depending on how credible it is".

Sensemaking, simply put, is to comprehend, understand, explain, attribute, extrapolate, and predict an unfamiliar situation or information (Starbuck and Milliken, 1988, Pg 51). As it can be seen, this is closely related to detecting and analysing weak signals or 'making sense' of weak signals. But weak signals theory does not seem to have been researched through the lens of sensemaking.

It must be noted that there are few papers within foresight which have used sensemaking, the research on the overlapping fields of sensemaking and weak signals (and foresight) is missing. As Sakellariou and Vecchiato (2022, Pg 01) state "Despite the promising potential of a productive overlap between sensemaking and foresight, these fields developed relatively discretely". Kaivo-oja (2012) suggests the use of knowledge management theories for analysis WS. But apart from this, there are not many papers that discuss WS with respect to sensemaking. Thus, looking at WS through the lens of sensemaking would be an interesting new avenue of research.

As Cuhls (2020) states, the making sense of WS (and other intelligence gathered) is particularly under researched in the field of foresight itself. This can be seen from the foresight process, as described by Cuhls (2020) which is shown in figure 10 below. The foresight process has four phases. Step 1, is to gather intelligence, that is detecting WS and trends. Step 2 involves making sense of the intelligence gathered. Step 3 is where priorities from all the sense making is selected which leads to decision making. In the final step, step 4, the final strategic decisions are implemented (Cuhls, 2020). But as Cuhls (2020) claims, the literature on sensemaking (step 2) is missing.

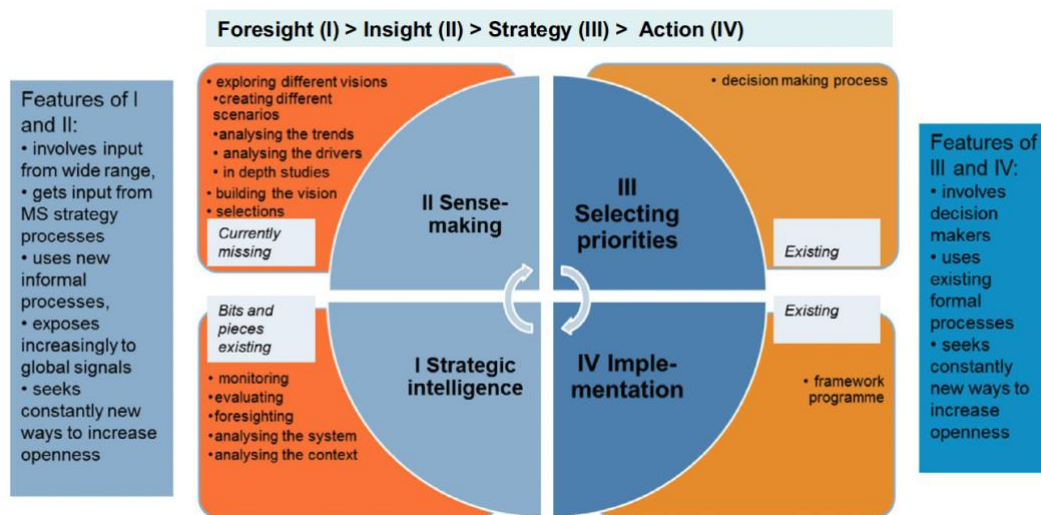


Figure 10: Foresight process
Source: Cuhls (2020)

Even though there are a few papers that have contributed to the filters and biases of WS detection, other aspects that have an influence on WS such as organisational and cultural issues to is scarce. Paper by Battistella and De Toni (2012) discusses about an organisation's design and its influence on WS detection. Roberto, Bohmer and Edmondson (2006) describe how organisation culture affects WS detection. Cunha and Chia (2007) suggest the use of dedicated teams for detecting WS as managers tend to be focused on tasks at hand. Apart from the organisational design, Haeckel (2004) discusses on other aspects such as heuristic models (Lesca, Caron-Fasan and Falcy, 2012) and intuition (Bertoncel et al., 2018) used by managers to make sense of WS. Non-involvement of the top management leads to misconception of WS and over-reliance on quantitative forecasting tools (Schwarz, 2005). But these organisational and personality aspects are under researched and in need for further empirical research to contribute to the field of WS.

Research gap: Empirical research on sensemaking (analysis), filters (biases), organisational factors, and personality attributes affecting the detection and

the analysis of WS is needed. This is particularly important for strengthening the foundation of weak signal theory.

3.6. WS application

WS are generally considered to be part of foresight or futures studies and has been traditionally associated with foresight tools such as environmental scanning systems, horizon scanning, peripheral scanning, etc. But some researchers have interestingly applied the WS concept to various other fields such as, for innovation (Könnölä, Brummer and Salo, 2007; Schirrmeister and Warnke, 2013) and entrepreneurial discovery (Gheorghiu, Andreescu and Curaj, 2016), for the prevention of work related illnesses (Liff, Eriksson and Wikström, 2017), for sustaining high quality performance (Su et al., 2014; Su and Linderman, 2016), for creation of economic calculus for investment returns (Dobrowolski et al., 2021), for forensic auditing (Dobrowolski, 2020), for security threat and controversial developments with emerging technologies (Boutellier and Biedermann, 2006; Hauptman and Sharan, 2013), for investment projects (Nikander and Eloranta, 1997), for project management (Nikander and Eloranta, 2001), for identifying young high potential researchers (Shin, 2015), for identifying attacks on mass transport (terrorism) (Koivisto, Kulmala and Gotcheva, 2016), and for preventing a whistle-blower situation by managing the cause early on.

Each of these fields are interesting application of WS theory. But as it can be seen there are one or maximum of two papers per topic. Thus, these application of WS to unique fields are not subject to critiques which would strengthen the potential of applying WS in other fields. This is a very practical research gap in need of theoretical as well as empirical research.

Research gap: There is need for empirical research to validate the pragmatic benefits of WS in areas other than foresight and future studies

3.7. Research agenda and research questions

As mentioned in the previous sections, it is relatively easy to spot weak signals retrospectively. Also missing in these papers are, what happened to the weak signals once they were detected? How did this affect or effect the development of strategic options or actions? This logical progression of weak signals into strategic options is missing and is in need of further investigation. Further, there is a scope of researching on the organisational aspect that affects the WS detection. For example, the personality traits of managers and its effect on WS detection or the relationship between organisational design and other organisational factors such as culture and its influence of WS detection. There are some papers that have proposed interesting and more pragmatic use of WS detection such as for innovation, terrorism etc., but there is a significant research gap that still needs to be addressed in future research. The following research gaps were identified for future research:

Research Gap 1: There is a need for debates on the philosophical points of view on WS for addressing the shortcomings in its definitions. More empirical research is needed to establish the benefits accrued by organisations which have sought WS.

Research Gap 2: Empirical research and validation are required for the quality weak signals detected by technology-enabled methods such as text mining and machine learning. Especially using explanatory or exploratory case studies in the present timeline rather than illustrative and retrospective case studies of events which have occurred in the past.

Research Gap 3: WS detection need to be subjected to more and varied empirical research.

Research gap 4: Empirical research on sensemaking (analysis), filters (biases), organisational factors, and personality attributes affecting the detection and the analysis of WS is needed. This is particularly important for strengthening the foundation of weak signal theory.

Research gap 5: There is need for empirical research to validate the pragmatic benefits of WS in areas other than foresight and future studies

Based on the research gaps identified above and considering the number of papers proposing the use of technology to identify WS, the author would like to establish a focussed research agenda through the following research questions for conducting an empirical study.

RQ1: How can Artificial Intelligence or Machine Learning enhance weak signal detection?

RQ2: How can Artificial Intelligence or Machine Learning alter the process of perceiving weak signals in the context of filters of weak signals?

RQ1 aims to address research gap 2 (mentioned above) with respect to using machines for weak signal detection. RQ2 explores the implications of using AI on filters of weak signals. This is an important research gap as the literature is sparse on filters of weak signals. RQ 2 aims to address part of research gap 4 (filters).

Considering today's world where technology has become a part of day-to-day life, huge amounts of digital data are being generated. But the effects of

filters during the transition of data to information in an increasingly dynamic world is underexplored. Overall, this thesis aims to contribute (by answering RQ1 & RQ2) to this underexplored but important area of research.

3.8. Research framework

Based on the research gaps identified earlier and after analysing the literature on weak signals, the following research framework will be used in this thesis.

Figure 11 below shows the various filters that weak signals pass thorough before becoming information for action. As depicted in the figure, this thesis will explore the how machines enhance weak signal detection and alter the perceiving of it (filters of weak signals). In the figure, 'machines' is inscribed within a horizontal rectangle. It is placed in between the environment and the activities of scanning, detecting, and perceiving. Metaphorically the rectangle will be opaque or transparent depending on the outcome of the research. That is, if the outcome is that machines enhance weak signal detection then the rectangle block will not be opaque. The bricked wall depicted is a metaphoric wall of filters. And the word 'machines' inscribed within a double headed arrow, depicts the exploration of this thesis on whether the bricked wall of filters will be reduced or amplified. This will be done by analysing the data collected by conducting a rigorous multi methods research through multiple case study, which would involve analysing machine learning output, semi-structured interviews, Miro board (digital) observation, and group observation. The details of this are presented in the data collection and analysis chapters.

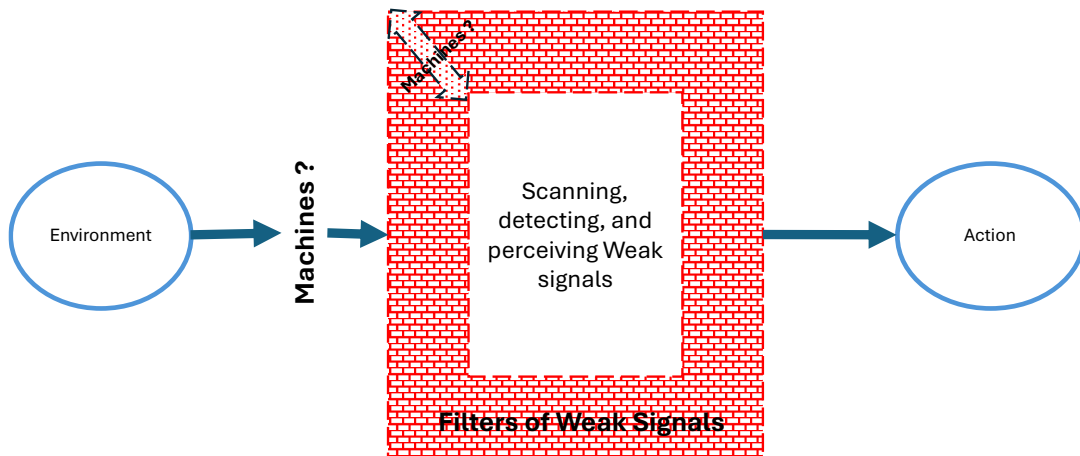


Figure 11: Research framework

Source: Author's own creation, adapted from Ansoff (1990)

Chapter conclusion

In this chapter a systematic literature review on weak signals theory was presented. Through this review important research gaps were identified and the research questions guiding this research were presented. The chapter began with the presentation of the WS theory and identified the research gaps to be addressed in future research with the WS theory itself. Based on complex systems view, questions were raised if it is indeed possible to detect weak signals. Next, various methods of WS detection was presented. But the major limitation with these methods is that they implicitly assume WS are out there that are waiting to be detected. This is problematic as before proceeding with WS detection, the critiques of WS theory needs to be addressed. Another major issue is that most of the papers use illustrative and retrospective? case studies to establish the empirical soundness of the proposed method. And in most cases the illustrative case would have already occurred in the past. The chapter concluded with identification of research questions and the development of a research framework that will guide the empirical research in this thesis.

In the next chapter an overview of the general methodologies in the business and management research will be presented. The next chapter will introduce the reader to the various ontological and epistemological views within the business and management research. Then the general methods within the business and management research are presented. This chapter sets the foundation for the following chapter in which the research methodology of this chapter is presented.

4. Overview of Research Methodologies in Business and Management

The aim of this chapter is to introduce the common research methods in business and management research. This chapter begins by presenting an overview of the various philosophical views. This is followed by an overview of various data collection approaches, data analysis, and theoretical inferences. This overview will provide the process map of the various options that can be followed by a researcher to design their methodology.

It is important to have a good research design as “research design is the general plan of how you will go about answering your research question(s). It will contain clear objectives derived from your research question(s), specify the sources from which you intend to collect data, how you propose to collect and analyse these, and discuss ethical issues and the constraints you will inevitably encounter” (Saunders, Thornhill and Lewis, 2015, Pg 163). Simply put, research method design should reflect that the researcher has diligently thought through the various elements of their research. The first element to consider is the philosophical position which is followed by the epistemological position. These two elements in-turn inform the choice of inference that will be used in the research. This is followed by the techniques that will be used for collecting data.

Figure 12 below shows the various options and choices available to researchers in business and management research.

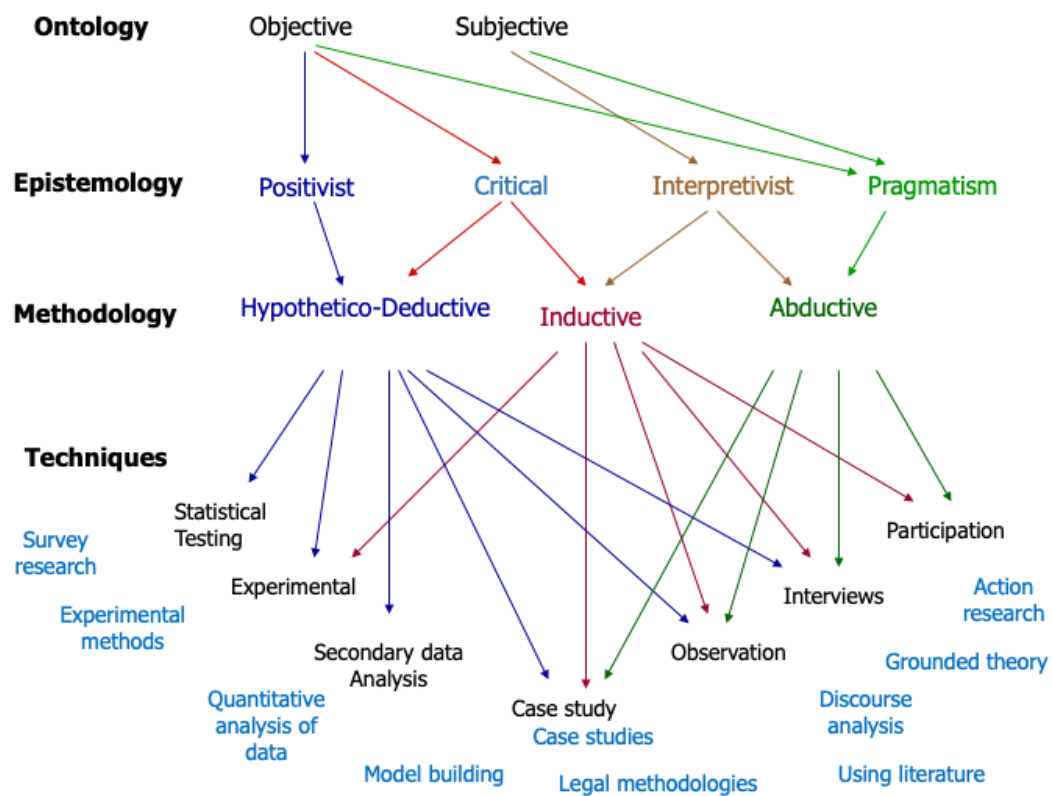


Figure 12: Research methodology
Source: Adapted from Birken and Quigley (2018)

In the following sections of the chapter, a brief overview of the research methods based on the template in figure 12 above. It would be beyond the scope of this thesis to present an in-depth critique and evaluation of various methodologies. But an overview is provided for paving the way for presenting the philosophical choice of the researcher of this thesis and for presenting arguments on how the methodological choice of the researcher suits the research aims of this thesis.

“There is no such thing as philosophy-free science; there is only science whose philosophical baggage is taken on board without examination” – Daniel Dennett, *Darwin's Dangerous Idea*, 1995

The quote above emphasises the importance and the crucial role of philosophy in management research. The lack of thinking and debating on the philosophical issues in research severely and negatively affects the quality of research (Easterby-Smith, 2012). As Saunders, Thornhill and Lewis (2015, Pg. 124) states "The term research philosophy refers to a system of beliefs and assumptions about the development of knowledge". The philosophical discussion is mainly centred around Ontology – the assumptions of reality, and Epistemology – the nature of enquiring the ontology. In the following sections a deeper and wider views of various ontological and epistemological assumptions are presented.

4.1. Ontology

"Ontology refers to claims regarding the nature and structure of being" (Rawnsley, 1998, Pg. 2). More simplistically put ontology is about the assumption of the nature of reality and existence (Easterby-Smith, 2012). The two main opposing ends of ontology are Realism and Nominalism as shown in figure 7. These views can be simplified as objective and subjective ontologies, respectively. It should be noted that the ontological beliefs are not binary, but, rather, it is a continuum in between the two ends (Saunders, Thornhill and Lewis, 2015). There is no right or wrong philosophical stance but rather it is based on the researcher's belief on the nature of the truth or knowledge (Bryman, 2012). The ontological beliefs generally vary between Nominalism, Relativism, Internal realism, and Realism. Nominalism and Realism represent the two opposing ends of the ontological realm. Figure 13 below presents the views on truth and facts through the different lenses of various ontological beliefs.



| Ontology | Realism | Internal Realism | Relativism | Nominalism |
|--------------|---------------------------------|---|---------------------------------------|-------------------------------|
| Truth | Single truth | Truth exists, but is obscure | There are many 'truths' | There is no truth |
| Facts | Facts exist and can be revealed | Facts are concrete, but cannot be accessed directly | Facts depend on viewpoint of observer | Facts are all human creations |

Figure 13: Ontology

Source: Adapted from Easterby-Smith (2012)

4.1.1. Nominalism

Proponents of nominalism believe that the social reality does not exist independently. Rather, it is the creation of people through language, discourse conceptual categories, perceptions, and consequent actions (Easterby-Smith, 2012; Saunders, Thornhill and Lewis, 2015). People who take the stance of nominalism are of the belief that each person's experience is different and therefore there are multiple realities. Thus, it is important to study these various realities rather than studying just one reality (Saunders, Thornhill and Lewis, 2015). To summarise, nominalism takes a view that there is no reality, and that reality is only a creation by humans.

4.1.2. Relativism

A less extreme view from that of nominalism is that of Relativism. As opposed to the view of Nominalism that there is no reality, relativism's view

is that there is, not one, but multiple reality (Easterby-Smith, 2012). As (Saunders, Thornhill and Lewis, 2015, Pg. 130) states "...reality is constructed through social interaction in which social actors create partially shared meanings and realities". The reason for this multiple reality is because the 'social interactions' of people are continuously evolving and revising (Saunders, Thornhill and Lewis, 2015). Thus, relativism advocates that the researcher should consider subjective attributes such as historical backgrounds, context, socio-cultural background, ethnicity, etc., to uncover the reality that was experienced by the object of study (Saunders, Thornhill and Lewis, 2015). To summarise, relativism accepts the notion of reality but advocates that there is not one single reality, but multiple realities exist.

4.1.3. Internal Realism

Moving on the scale of ontology and tipping towards objectivism is Internal Realism. Internal realism accepts that there is a single reality but, it maintains that it not possible to access this reality directly. And that researchers can only indirectly access this reality (Easterby-Smith, 2012). Drawing on an analogy in line with Easterby-Smith (2012) to explain this concept of internal realism, an interesting analogy would be that of a wind tunnel experiments. The scientists add colours to the wind introduced into the tunnel to understand how it flows around an airplane/car to draw conclusion. If the colour were not added the scientist could not have observed how the wind flowed around the plane which would have occurred even without the coloured wind. Hence the stance of internal realism that there exists a reality, but it can be accessed indirectly.

4.1.4. Realism

At the other end of the scale is pure objectivism – Realism. Realism postulates that there is a physical reality which can be accessed through rigorous research, and it is independent of the researcher or the observer. Easterby-Smith (2012, Pg. 19), states that in the lens of realism “.... the world is concrete and external, and that science can progress only through observations that have a direct correspondence to the phenomena being investigated”. It is worth mentioning that this stance has been slightly modified by researchers over the years to accommodate the laws nature and not just the laws of physics giving raise to Bhaskar’s transcendental realism (Easterby-Smith, 2012).

In this section a brief overview of the main ontological stances was presented. In the following section discussions of the various epistemological beliefs will be presented.

4.2. Epistemology

Epistemology is the different ways of studying the nature of knowledge (ontology) and the ways in which this study can take place. Easterby-Smith (2012, Pg. 21) states that “epistemology is the study of the nature of knowledge and ways of enquiring into the physical and social worlds. It is, as we have indicated, the study of theories of knowledge; how we know what we know”. The epistemological stances are based on the way at which a researcher looks at knowledge. That is, one view is that knowledge is ‘a priori’ – Where knowledge is inherent and is independent of sensory perceptions or experience. The other view is that of ‘a posteriori’ – Here knowledge is acquired from experience (Rawnsley, 1998). Based on the assumption of knowledge there are different epistemological stances for e.g., logical positivism, rationalism, empiricism, pragmatism etc. These became

known as paradigms and the word paradigm came into vogue after the book on scientific revolutions by Kuhn (Kuhn, 1962; Easterby-Smith, 2012).

Though there are multiple epistemological stances, three key stances – Interpretivism (subjective ontology), Positivism (realist ontology), and Critical Realism (internal realism) – that are commonly used in the social sciences are presented. This is then followed by a brief introduction to pragmatism as pragmatism has both objectivity and subjectivity embedded in it. The first is Interpretivism which is based on the nominalist ontology

4.2.1. Interpretivism

Interpretivism was born as an opposition to positivist thinking. A lot of thinkers were of the belief that the normal rules of physical sciences could not be applied to social sciences as humans were different from objects (Saunders, Thornhill and Lewis, 2015). The main difference being the ability to give meaning. Thus, there was a need to interpret these meanings and feelings, and this could not be done in the same way as the physical sciences. From this need arose Interpretivism. Interpretivism can be traced back to works of European thinkers, mainly from Germany and France. The main contention of Interpretivism against positivism is that there are different people with different cultures, different backgrounds and circumstances and thus taking different meaning of reality at different times. Therefore, it is not possible to establish universal law-like conclusions that positivists aspire (Saunders, Thornhill and Lewis, 2015). On the other end of the contrast is the Positivist epistemology. The positivist epistemology is based on the realist ontology.

4.2.2. Positivism

Positivism or The Positive Philosophy was introduced by Auguste Comte – A French philosopher (Comte, 1974) and he is also credited for coining the term sociology. Comte believed that the positive methods of natural sciences would eventually prevail in politics and thus paving way for a “positive science society, which is called Sociology” (Burrell, 2005, Pg. 42).

Comte believed that knowledge, to the human mind, travels through three stages – The first stage being the theological stage, followed by the metaphysical state and finally the positive state. The theological state is the search for knowledge of all ‘essential nature of beings’ in other words, the answer to all phenomena by the action of supreme being – e.g., God, Spirits etc. (Comte, 1974; Hassard, 1995). In the metaphysical state, the human mind transverses from the first stage to a stage where there the human mind believes that ‘abstract forces and veritable entities’ are capable of producing all phenomena (Comte, 1974, Pg. 26).

In the final journey, the human mind, reaches the third stage – positive state. Here, the human mind moves from the search for the absolute answer for all phenomena to the study of the laws that apply to the phenomena. In other words, the human mind starts to apply itself to the study of the reasoning, observing and connecting all phenomena and further study the ‘invariable relationship of succession and resemblance’ (Comte, 1974, Pg. 26).

Simply put, “The crux of positivist inquiry is that we can only have true knowledge of explicit phenomena and the relationship between them” (Hassard, 1995, Pg. 06). The core foundation of The Positive Philosophy is that, once the human mind reaches the positive state, the mind gains

knowledge through "[The] stating of normative, systematic and law-like relations between empirically observable data" (Hassard, 1995, Pg. 06).

In summary, positivist research has the following characteristics (Ates, 2008, Pg 54):

- Independence – the observer is independent of what is being observed
- Value-free and scientific – the choice of subject and method can be made objectively, not based on beliefs or interests
- Hypothetico-deductive – hypothesise a law and deduct what kinds of
- Observations will demonstrate its truth or falsity
- Large samples
- Empirical operationalisation – typically quantitative
- Principles of probability
- Reductionism – break problems down into their smallest elements
- Generalisation – sufficient samples should be selected in order to generalise to a population

4.2.3. Critical realism

The evolution of critical realism can be traced back to the work of philosopher Roy Bhaskar (Bhaskar, 1975). The main argument of critical realism is based on the 'epistemic fallacy' (Warwick_Education_Studies, n.d). That is, what we say is 'real' is in fact the observable truth which is influenced by the actual 'reality'. But this actual 'real' is unobservable. Critical realism is considered as a middle ground between pure positivism and pure constructivism and one of the key features of Critical Realism is 'structured ontology' (Easterby-Smith, 2012). This has three levels: The first is the *empirical level* which is nothing but the experiences of people. The second

level is the *actual level* is where events take place – whether observed or not. The third level is *real level* which contains the ‘causal powers and mechanisms’ which cannot be detected directly. These three levels, as Easterby-Smith (2012, Pg 59) states, “correspond roughly to three of the ontological positions: respectively relativism, internal realism and realism”.

4.2.4. Pragmatism

The origins of pragmatism can be traced to the works of philosophers Charles Pierce, William James, and John Dewey in the late 19th century USA. Pragmatism places importance on how research contributes practical solution that ‘inform future practice’ (Saunders, Thornhill and Lewis, 2015). Pragmatism strikes a balance between objectivism and subjectivism. As, in pragmatism, the ‘reality’ is considered too dynamic and hence attempting to access this is futile. But nonetheless reality does exist. Thus, Pragmatism is able to accommodate various theories, concepts, methods, and research findings as the contribution and consequences of the research is of importance rather than methods or theories itself.

Table 10 below shows the ontology, epistemology, and typical methods for positivism, interpretivism, critical realism, postmodernism, and pragmatism.

Table 10: Common research paradigms

| Ontology (nature of reality or being) | Epistemology (what constitutes acceptable knowledge) | Typical methods |
|--|---|------------------------|
| Positivism | | |

| | | |
|---|---|---|
| Real, external, independent | Scientific method | Typically deductive, highly structured, large samples, |
| One true reality (universalism) | Observable and measurable facts | measurement, typically quantitative methods of analysis, but a range of data can be analysed |
| Granular (things) | Law-like generalisations | |
| Ordered | Numbers | |
| | Causal explanation and prediction as contribution | |
| Critical Realism | | |
| Stratified/layered (the empirical, the actual and the real) | Epistemological relativism | Retroductive, in-depth historically situated analysis of pre-existing structures and emerging agency. |
| External, independent | Knowledge historically situated and transient | Range of methods and data types to fit subject matter |
| Intransient | | |
| Objective structures | Facts are social constructions | |
| Causal mechanisms | Historical causal explanation as contribution | |
| Interpretivism | | |

| | | |
|--|---|---|
| Complex, rich, socially constructed through culture and language | Theories and concepts too simplistic | Typically inductive. |
| Multiple meanings, interpretations, realities | Focus on narratives, stories, perceptions, and interpretations | Small samples, in-depth investigations, qualitative methods of analysis, but a range of data can be interpreted |
| Flux of processes, experiences, practices | New understandings and worldviews as contribution | |
| Postmodernism | | |
| Nominal | What counts as 'truth' and | Typically, deconstructive |
| Complex, rich | 'knowledge' is decided by dominant ideologies | – reading texts and realities against themselves |
| Socially constructed through power relations | Focus on absences, silences and oppressed/ repressed meanings, interpretations and voices | In-depth investigations of anomalies, silences and absences |
| Some meanings, interpretations, realities are dominated and silenced by others | Exposure of power relations and challenge of | Range of data types, typically qualitative methods of analysis |
| Flux of processes, experiences, practices | | |

| | | |
|---|---|---|
| | dominant views as contribution | |
| Pragmatism | | |
| Complex, rich, external 'Reality' is the practical consequences of ideas Flux of processes, experiences and practices | Practical meaning of knowledge in specific contexts 'True' theories and knowledge are those that enable successful action Focus on problems, practices and relevance Problem solving and informed future practice as contribution | Following research problem and research question Range of methods: mixed, multiple, qualitative, quantitative, action research Emphasis on practical solutions and outcomes |

Adapted from Saunders, Thornhill and Lewis (2015); Bryman (2012); Easterby-Smith (2012)

4.3. Method

As Easterby-Smith (2012, Pg. 68) states that the "... essence of research design: it is about making choices about what will be observed, and how". From the previous statement research design has two important aspects: what is observed and how. In the previous sections different ways in which a phenomenon can be observed was presented. In the following section, the different tools that would aid in observing the phenomenon depending on the philosophical lens will be presented.

4.3.1. Overview of methods

In this section a general overview of the various methods commonly used in management research will be presented. The various methods will be presented by clustering them based on the philosophical stance that the respective method most relates to as presented in figure 14 below. This is adapted from the similar framework used by Easterby-Smith (2012). The Y axis represents the detached stance on research at one end and the other end is the involved stance on research. The X axis has the positivist stance at one end and the constructionist stance at the other end. The A, B, C and D form quadrants with respect to X and Y axis. Example, a method in quadrant A would mean that the researcher takes a detached role and has a positivist belief.

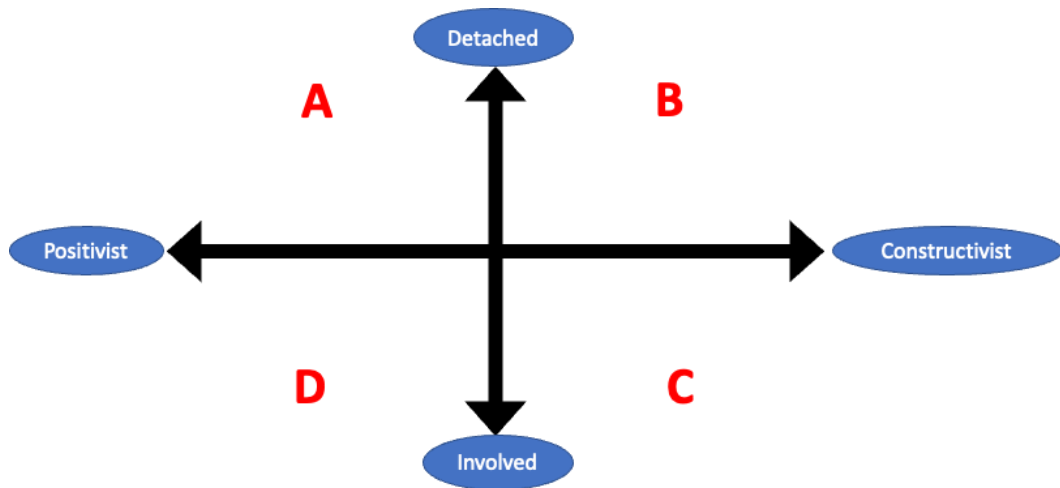


Figure 14: Paradigm and methods

Source: Adapted from (Easterby-Smith, 2012)

4.3.2. Case study

Case study research is one of the most versatile research methods which can accommodate research from various philosophical beliefs. For instance, case study can be a method used by positivists as well as constructivists. One of the most used case study research books is by Robert Yin (Yin, 2014). He comprehensively and clearly summarizes what case research by way of systematically defining case study. There are two parts of the definition. The first part states that "A case study is an empirical method that investigates a contemporary phenomenon (the "case") in depth and within its real-world context, especially when the boundaries between phenomenon and context may not be clearly evident. In other words, you would want to do a case study because you want to understand a real-world case and assume that such an understanding is likely to involve important contextual conditions pertinent to your case" (Yin, 2018, Pg. 45, 46).

The second part states "A case study copes with the technically distinctive situation in which there will be many more variables of interest than data points, and as one result benefits from the prior development of theoretical

propositions to guide design, data collection, and analysis, and as another result relies on multiple sources of evidence, with data needing to converge in a triangulating fashion” (Yin, 2018, Pg. 45, 46). The two-part definition very clearly and comprehensively paints a picture on what case study research is. Typically, but not always necessarily, a single case study method is taken up by a constructivist and a multiple case study is taken up by a positivist (Easterby-Smith, 2012).

The general types of case study methods are comparative case study, longitudinal case study and explorative case study (Easterby-Smith, 2012). Even though the dominant view of case study design has been from the positivist view, it has been used by constructivists alike. Thus, the case study is not classified under any particular quadrant as this method is used by both positivists as well as by constructivists (Easterby-Smith, 2012).

4.3.3. Quadrant B & C – The constructionist design

4.3.3.1. Action research and co-operative enquiry

Action research is broad and there is no single accepted method of doing action research. Action research typically involves the researcher being a part of the setting where a solution needs to be found. Data collection is typically done whilst participating in the problem-solving setting. The researcher can collect both qualitative as well as quantitative data. Action research is common in the fields of social sciences and business and management studies. The main critique is that action research lacks in rigour and is too biased (Bryman, 2012).

4.3.3.2. Archival research

This is a method in which the researcher uses the available historical data to conduct research. Examples of such data could be company report, CEO statements, financial reports, meeting report, government reports, annual reports, etc. Even though both quantitative data is available, the focus is on the words and text in the data (Easterby-Smith, 2012).

4.3.3.3. Ethnography

In this method, the researcher immerses themselves in the research setting. And becomes a part of the study (or group) in order to understand the meanings and significance that people give to the behaviour of the researcher as well as others. The research can be either participatory or non-participatory. In participatory ethnography, the research would be a part of the observation whereas in non-participatory research the researcher would not take part in the observation. The main feature of ethnography is the time frame. The observation is over a long period of time (Leavy, 2017).

4.3.3.4. Grounded theory

Glaser and Strauss are credited for developing the grounded theory method (Easterby-Smith, 2012). "Grounded theory has been defined as theory that was derived from data, systematically gathered and analysed through the research process. In this method, data collection, analysis, and eventual theory stand in close relationship to one another" (Strauss and Corbin 1998 in Bryman, 2012, Pg. 387).

As Easterby-Smith (2012, Pg. 92) states "They [Glaser and Strauss] saw the key task of the researcher as being to develop theory through 'comparative

method', which means looking at the same event or process in different settings or situations". But as the method developed there were differences between Glaser and Strauss. Glaser was of the belief that that a researcher must be grounded in data. That is, a researcher must start his research with no presumptions of data and that theory must emerge by connecting through data. Strauss deviates here and says that the researcher must familiarise himself/herself with the some existing theories before connecting to data (Easterby-Smith, 2012).

4.3.4. Quadrant A & D – The positivist design

The main methods in this positivist paradigm are experimental research and survey research. A brief introduction the experimental and survey methods is presented below.

4.3.4.1. Experimental methods

The experiment method is considered as gold standard research in the realist research methodology. Experimental research is often explanatory research (Leavy, 2017). The experiment is derived based on the natural sciences especially the medical sciences (Saunders, Thornhill and Lewis, 2015). The experiments generally involve the study if an independent variable causes an effect on a dependent variable. Experiments generally involve the testing of hypothesis as the researcher anticipates if an independent variable has an influence over a dependent variable. In a classic experiment, participants from a sample are randomly assigned to either control group or experiment group. In the experiment group, the planned intervention is introduced, and the effects are measured against the control group where no interventions

are introduced. The changes, if any, are observed and recorded. Thus, the researcher can conclusively state that the intervention causes the change (Saunders, 2015).

4.3.4.2. Survey research

Survey research is usually done to establish a relationship between two or more variables. Surveys are usually administered via post, telephone, in-person, and more recently and more commonly via internet (mobile and computers). A survey is designed to capture data from the questions posed. The data collected is usually quantitative or is converted into a quantitative value. Using this quantitative data, various modelling techniques are applied on it to test the hypothesis. The most common modelling methods are regression analysis.

As Bryman (2012, Pg. 60) states "Survey research comprises a cross-sectional design in relation to which data are collected predominantly by questionnaire or by structured interview on more than one occasion and at a single point in time in order to collect a body of quantitative or quantifiable data in connection with two or more variables which are then examined to detect patterns of association (Bryman, 2012. Pg. 60)".

Chapter conclusion

In this chapter the various methodologies within the management research were presented. This chapter began with the presentation of common ontological and epistemological views within the business and management research. Then the common methods used in the management research were presented by grouping them based on the characteristic of the method and matching that to the respective philosophical view. This general

introduction will act as the foundation for presenting the methodological choices of this thesis. This will be presented in the next chapter.

5. The Research Design

In the previous chapter the various methodologies in management research were presented. In this chapter, arguments for the methodological choice for this thesis is presented. The chapter begins with the arguments for the philosophical choice of the author – Pragmatism. This is followed by a brief discussion on the three theoretical inference logics: inductive, deductive, and abductive. Following this the researcher's choice of abductive logic is presented. Finally, mixed method case study research method is presented as the method of choice for this research.

5.1. Philosophical choice: Pragmatism

The quote above emphasises the importance of philosophy in research. The lack of thinking and debating the philosophical issues in research will reflect on the quality of research (Easterby-Smith, 2012). From the previous chapter where the different philosophical stances were introduced, it is clear that every research is based on the stance, beliefs, and preferences of the researcher. If not, then, perhaps, there would be one stance accepted by all the researchers. As Saunders, Thornhill and Lewis (2015. Pg 124) states "The term research philosophy refers to a system of beliefs and assumptions about the development of knowledge". Thus, this section will present the philosophical beliefs and assumptions of the researcher.

With the researcher having spent almost 12 years of his career in a manufacturing setting, it was but natural to be inclined towards the

positivist's paradigm. It made complete sense for statements such as "That tree in the forest is a tree, regardless of whether anyone is aware of its existence or not" (Crotty, 1998. Pg 9). Industrial production of a products based on an engineering drawing would produce the same product, within accepted tolerances, if the drawing were followed diligently. Thus, the positivist ontology that there is an external reality which can be accessed made sense.

But the statement by Heraclitus that "Everything changes, and nothing remains still [...] and [...] you cannot step twice into the same stream" (Sminia, 2018) challenged the previous positivist belief of the researcher. That is, if the reality is ever changing then how can it be sought? The statement by Heraclitus has a profound impact on this thesis as it questions the assumption of an objective view that reality can be accessed. Second it also questions the constructionist view that reality is a construct of humans since the statement indicates that there is a reality just that it cannot be accessed. This dualist nature of the traditional philosophical stances commonly portrayed by business and management research, Burrell (2005), presented a problem as it was not sitting well in the beliefs of the researcher.

Another problem of objective or subjective philosophical stance is that there is an intrinsic assumption that the researcher is rational and free from bias and therefore can arrive from data analysis to a theoretical conclusion. This assumption of rationality is far from reality (Saku and Mikko, 2013). It is therefore unrealistic to prescribe to the standard dualist approach of philosophical views, to be objective or subjective, means taking a rational stance. And, as mentioned earlier, it highly unlikely to find a rational researcher. As Saku and Mikko (2013. Pg 71) state "...researchers are just as human as managers and that there is little evidence that researchers face different cognitive constraint".

Thus, there was a conflict in looking at research from a dualist point of view. Pragmatism overcomes this dualists stance by taking a view that humans are part of the environment and thus influence the reality around them (Moshe, Christopher and Arjen, 2015). Hence, the reality is dynamic and constantly evolving, and therefore futile to search for it (Simpson, 2018). Pragmatism is of the view that gaining knowledge is a "continuum" between objective and subjective rather than belonging to one of the sides (Goles and Hirschheim in Kaushik and Walsh, 2019).

Pragmatists view that the best way to seek and enhance knowledge is to solve the problem that is being posed. This is similar to the researcher's experience in a manufacturing setting where the priority was for solving the problem at hand for which it was acceptable to use frugal innovative approaches. The knowledge gained from solving the problem would be transferred by either updating the standard operating procedures (SOP) or updating the knowledge bank. Therefore, the knowledge contained in the SOPs was dynamic as opposed to the view held by subjective/objective views of knowledge. Pragmatism advocates similar opinion of being practical. It emphasises the importance of knowledge being practical, and making a difference rather than attempting to vainly relate to some "elusive reality" (Johnson, 2007). Pragmatism aims at solving "real world problems" (Yvonne Feilzer, 2010).

Rorty, who is credited for reviving the interest in pragmatism (Baert, 2005), states that "the pragmatists criterion for knowledge is practical utility rather than ontological reality" (Rorty, 1998 in Johnson, 2007). He further states that "the test of knowledge is not its correspondence to some reality, but its contribution to coping better in everyday life and to sustaining better conversation in science" (Rorty, 1998 in Johnson, 2007). Pragmatism emphasises practical answers to research questions and practitioners of pragmatism are of the belief that, as pointed previously, practicality is more

relevant to answering research rather than trying to vainly attempt to access an obscure reality. As Simpson (2018, Pg 20) states "In an ever-changing, probabilistic world then, far from being immutable facts proposed by Descartes, the beliefs that guide our actions are our best guesses, or bets, about how things will turn out if we act this way or that".

There are four themes of Pragmatism, Inquiry, Habit, Experience, and Transaction (Elkjaer and Simpson, 2011). Experience is formed by the sources of people's beliefs and the meaning of people's actions. Experience always involves interpretation, that is "beliefs need to be interpreted to generate action and actions must be interpreted to generate beliefs" (Morgan, 2014, Pg 2). Habit is nothing but what has been acquired from previous experiences (Morgan, 2014) (Elkjaer and Simpson, 2011).

Inquiry is at the heart of Pragmatism and is based on doubt and belief where doubt is "some form of disruption to thinking and action" and belief is the "state of resolution" after the doubt is addressed (Elkjaer and Simpson, 2011). Dewey, one of the original proponents of Pragmatism, is of the view that inquiry is akin to scientific research as it involves careful reflective decision making (Morgan, 2014).

Lastly, Pragmatists are of the opinion that meanings emerge due to the interactions amongst various people and are shaped by gestures amongst themselves rather than meaning constructed amongst themselves. Thus pragmatism advocates that social practices, and therefore research, are emergent and continuous which are influenced by individual as well as social situations (Elkjaer and Simpson, 2011). Thus, all the four themes of Pragmatism together simplify Pragmatism as a practical approach with a focus to solve the problem at hand.

In the preceding paragraphs the philosophical stance of Pragmatism was introduced. An argument against the dualistic stance of the traditional philosophical views and an argument for the pluralistic stance of pragmatism was presented. Further, it was discussed as to how views of Pragmatism are in line with the personal views of the researcher. Now, the following section will present how the research of this thesis fits well with Pragmatism.

The research in this thesis is on exploring the how machines affect the detection of weak signals and perception of it (filters of weak signals). As presented in the literature review chapter, weak signals (WS) are by nature vague and is surrounded by noise. The seeker of WS should clean the noise and amplify the signal to interpret its meaning. These weak signals can be developed into future scenarios. Future scenarios are scenarios where the past and the present are woven together to establish a causal chain of the future. Since scenarios are concerned with the future, it becomes difficult to address the question of reality in terms of the dualist philosophical views – Positivist and the anti-positivists arguments.

Assuming the shoes of a positivist, it could be possible to access the reality of the past and even the present. But it is just not possible to access the reality of the future, since it does not exist, or it is yet to be. From a subjectivist point of view that reality is a human construction, or even the extreme form of subjectivists where there is no reality, it would be pointless to understand the causal chains to build scenarios of future since reality is constructed and is therefore something that cannot be sought as various players would construct it differently. But there are abundant literature stating the benefits of foresight and there are organisations, some of them profit making, who practise strategic foresight as means of staying competitive.

This puts the traditional philosophical stance with the dualist view on unstable grounds when looking into the possible futures. But Pragmatism is in a perfect position to address this conundrum as, in the lens of Pragmatism, reality is dynamic and therefore it is futile to access it but nonetheless reality exists. Therefore, for a Pragmatist, it is possible to imagine multiple realities of the future without the concern of reality. Which is a concern within the dualist view of philosophy. To support this is another important aspect of Pragmatism is the view of temporality, that is "both the past and the future are in the actions of the present" (Simpson, 2009. Pg 1337). This has an important impact on strategic foresight as foresight is on acting today for the possible future.

The thesis aims to explore how machines enhance the detection of weak signals and alters the perceiving of it (filters of weak signals). This involves the use of a machine learning model (Latent Dirichlet Allocation) which is a quantitative model. Additionally multiple qualitative explorative methods (interviews and observations) are used to address the research questions. Thus, this thesis is multi-methods research.

The multi methods research does not go well with the people who prescribe to the dualist philosophy. These people either take the realists stance that reality exists and can be accessed or, at the other end of the spectrum, take the stance of nominalist that there is no reality. Thus, their access to research methods is limited by their inflexible views of reality and knowledge. There are words of caution in most of the research methods books on carrying out such mixed or multi methods research as they suggest that it is difficult to justify such research philosophically (For e.g., see Bryman, 2012). Even though methods and paradigms cannot be connected, there seems to be an affinity of certain paradigms to certain method. The common claim being qualitative to constructionism and quantitative to positivism (Morgan, 2014). But what is certain, due to the dualist view of the traditional

philosophies, is the choice of a single method. But the research questions addressed herein are done using multi methods which does not fit well with the dualist philosophies.

This is where Pragmatism is at an advantage as it advocates using any available tool to address the problem (Creswell, 2013; Onghena, Maes and Heyvaert, 2019). Many researchers today consider that pragmatism as a paradigm for multi or mixed methods research (Onghena, Maes and Heyvaert, 2019). But this has led to a common misconception that pragmatism is a shortcut for justifying multi method research, and clearly it is not (Simpson, 2018). Having presented the arguments above, it can be claimed that this thesis does not use a shortcut to justify multi methods. Rather it uses Pragmatism because the phenomena being investigated fits well with the personal preferences and beliefs of the researcher.

5.2. Methodological choice: Abductive approach

One of the most important parts of a good research is theory. Thus, it is important to understand what theory is. Theory is critical to the advancement of organisational studies (Ashkanasy, 2016). Thus, Ashkanasy (2016) suggests that the main aims of research should be theoretical contribution. Theory is important as it gives context to the research being done as well as a framework within which the research can be interpreted (Bryman, 2012). Huffman and Dowdell (2015) in Ashkanasy (2016. Pg. 1) define theory as "a systematic, interrelated set of concepts that explain a body of data". Another similar definition is "Theories are sets of organizing principles that help researchers describe and predict events" (VanderStoep, 2009. Pg 4)

But it is difficult perceive what theory is, as the perception of theory changes by a researcher's background. A common example is the use of the word theory colloquially by non-researchers to emphasis a claim on their knowledge of a phenomenon or for the lack of physical demonstration of the phenomenon. For instance, an individual stating in common social conversations "Well... theoretically...". So, the question remains – What is theory? To address this question Sutton and Staw (1995) take a different approach by stating what theory is not. As per them, theory is not references, data, variables, diagrams, or a set of hypotheses. But, a theory is something that should could make way for generation of hypotheses that can be tested (VanderStoep, 2009).

The theoretical contribution of research is usually done either by generating (or extending) theory through inductive research or through testing existing theory through deductive research (Bryman, 2012). Further, in the field of business studies and social sciences, research is mainly to build upon theory (Stockemer, 2019). Even though the inductive and deductive approaches to theory are elaborated in most of the handbooks on research, there is a third way – Abduction.

As Lee (2008) and Wengel (2019) point out, in practice it is sometimes difficult to stick to one style of reasoning and it is commonly observed that researchers often move back and forth between inductive and deductive. Thus, the Pragmatic approach subscribe to a combination of both inductive and deductive approaches known as Abduction (Farquhar, 2012). In the following sections, the three forms of research logic – inductive, deductive, and abductive – will be presented with an emphasis on abduction as this is the methodological choice of this thesis. Further, how abduction is suited for addressing the research questions of this thesis is presented.

5.2.1. Inductive research

In inductive research, the researcher aims to generate a new theory through examination, exploration, and understanding of data (Farquhar, 2012). A trait which is generally associated with qualitative researchers (Bryman, 2012; Easterby-Smith, 2012). The inductive process starts with observations which leads to theory and is particularly evident in the grounded theory approach (Bryman, 2012).

5.2.2. Deductive research

In deductive research, the researcher, based on the existing knowledge, proposes a hypothesis to test the existing theory and confirms it or rejects the theory. As per Bryman (2012, Pg. 24) "Deductive theory represents the commonest view of the nature of the relationship between theory and social research". Post proposing the hypothesis, the researcher would choose the right tool(s) for data collection and analyses the data to either confirm or reject the hypothesis.

5.2.3. Abductive research

Abduction is the development of a plausible explanation for a surprising fact or a theoretical idea or an observation (Teddle, 2009; Farquhar, 2012; Saunders, Thornhill and Lewis, 2015). Peirce (Charles Sanders Peirce), one of the founders of Pragmatism, proposed abduction as "an inferential logic that complements and extends deduction and induction" (Simpson, 2018. Pg 7). Further, Peirce proposes that "It [Abduction] is the only conceivable source of novelty in thinking/doing as it suggests the possibility 'that something may be', while 'Deduction proves that something must be

[and] Induction shows that something actually is operative” Simpson (2018. Pg 7).

Table 11 illustrates the differences of the three forms of inferences. This is drawn from the example of beans given by Peirce (Peirce in Simpson, 2018). Teddlie (2009. Pg. 83) provides a logical statement to explain the abduction process of logical inference as shown in figure 15.

“The surprising phenomenon, X, is observed.
 Among potential hypotheses A, B, and C, A is capable of explaining X.
 That is, if A were true, then X would be a matter of course.
 Therefore, there is reason to believe that A is true”.

Figure 15: logic statement of abduction
 Source: (Teddlie, 2009)

Table 11: Three logics of inference

| Three logics of inference | |
|----------------------------------|---------------------------------------|
| Deduction | |
| Rule | All the beans from this bag are white |
| Case | These beans are from this bag |
| ∴Result | These beans are white |
| Induction | |
| Case | These beans are from this bag |
| Result | These beans are white |
| ∴Rule | All the beans from this bag are white |
| Abduction | |

| | |
|--------|---------------------------------------|
| Rule | All the beans from this bag are white |
| Result | These beans are white |
| ∴Case | These beans are from this bag |

It would help to recall the research framework presented in the literature review chapter to link the choice of abductive logic of inference in this thesis.

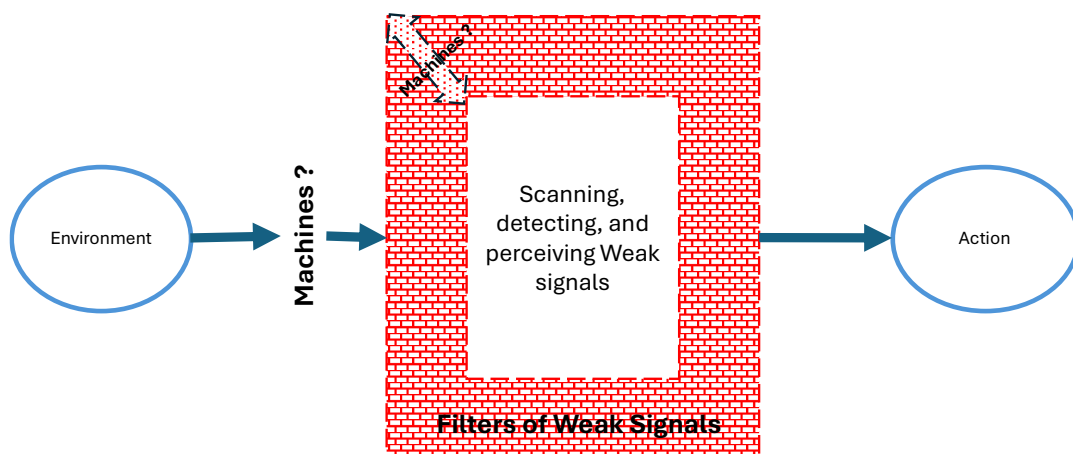


Figure 16: Research Framework

Source: Author's own creation, adapted from Ansoff (1990)

As shown in the framework above, this thesis, drawing on the previously mentioned logic of abduction, explores the how machines enhance weak signal detection and alters the perceiving of it (filters of weak signals). To do so, this research is guided by two research questions:

RQ1: How can Artificial Intelligence or Machine Learning enhance weak signal detection?

RQ2: How can Artificial Intelligence or Machine Learning alter the process of perceiving weak signals in the context of filters of weak signals?

Presently there are no established benchmarks or measures to understand if machines can enhance weak signal detection which is investigated in RQ1. Similarly, RQ2 which explores how machines alter the process of perceiving weak signals, as with RQ1, there are no established benchmarks or measures.

These challenges make using inductive and deductive difficult as “Deduction proves that something must be [and] induction shows that something actually is operative” (Simpson, 2018. Pg 7). Clearly these two methods of inferences are not possible in this research. As, given the challenges, it is not possible to prove ‘something must be’ which would mean establishing a rule on the lines of realist thinking. Also, showing ‘something is operative’ is difficult to achieve. As isolating the operative link is difficult in this research setting. But abduction suggests the possibility ‘that something may be’ (Simpson, 2018. Pg 7). This is suited for this research, as given the challenges mentioned previously, it is possible to establish that ‘something may be’. The abductive logic of inference for this thesis can be shown by the logic from figure 15. Where the rule is that there are filters which alter the weak signals. The result will be the result from this research. And therefore,

the case being “Inference to the Best Explanation” (Douven, 2021) of machine learning’s effect on filters.

5.3. Research method: Case study

The ontological, epistemological, and methodological preferences of a researcher have bearing on the choice of research method. For instance, the dominant paradigm of survey and experiment research is objective and positivist (Easterby-Smith, 2012). Similarly, the dominant paradigm in qualitative research and case study research is subjective and constructivist. But it should be noted that it is completely wrong to tie methods to research paradigms (Morgan, 2014). Rather methods are purely the choice of the researcher, and this choice is influenced by the beliefs of the researcher.

This thesis will be based on the case study research method. As mentioned previously, this thesis explores machine learning with respect to detection and filters of weak signals within the context of strategic foresight. This entails that the researcher must have access to people who have participated in a scenario planning project. Even though there are multiple ways to achieve this, for e.g., experiment research or action research, justification is provided below as to why case study research method is the method of choice for this thesis.

Though there are no right and wrong methods (Wengel, 2019), each method has its own advantages and disadvantages, and the researcher must make an informed choice that will enable conducting a rigorous and reliable research. As Ates (2008. Pg 91) states “All methods have benefits and drawbacks; however, my main purpose is to trade-off between methods in the light of my working paradigm and to choose the most appropriate and advantageous method which will provide reliable and rigorous answers to my research questions”. Thus, the case study method will be contrasted against

some of the popular choices of business research methods such as, survey, experiment, and participatory methods to provide justification for the chosen method.

The choice of a method is not just limited to the philosophical beliefs of the researcher, there are practical aspects that need to be considered as well such as funding, researcher's expertise, access to data, institutional preferences etc. (Wengel, 2019). Thus, to justify the choice of case study as the right method fit for this thesis, case study method will be contrasted with experiment and participatory research methods such as action research. As these methods could arguably be used to achieve the research aims of this thesis in place of case study research. The following criteria will be used evaluate and contrast case study with that of experiment and participatory methods such as action research.

- i. Access to data.
- ii. Researcher's expertise.
- iii. Research objective posed.

5.3.1. Case study versus experiment

Experiment research, in the social sciences, is "a research methodology which involves collecting primary data from individual decision-makers who face real payoffs from their responses" (Croson, Anand and Agarwal, 2007, Pg 173). That is, experiments involve treatments where some participants see standard (or the status quo) material and other participants see the treated or changed material. The outcome is compared to make inferences. There are different kinds of experiments; the common types being the lab experiments – which is more favoured by the physical and medical sciences – and field experiments which are more favoured by the social scientist.

The debate on the use of experiments, its advantages, its disadvantages, its criticisms, its acceptance, etc., is a vast subject and there is quite a good amount of literature surrounding it. For example see: Croson, Anand and Agarwal (2007); Falk and Heckman (2009). Within experimental research, field experiments are more commonly used in strategic management research (Chatterji et al., 2016).

Thus, for conducting an experiment it is first important to establish what needs to be measured which is the variable(s). Then a robust method to measure the variables needs to be established. Measures for variables such as productivity and pay (for e.g., see: Dohmen and Falk (2011)) is relatively easy as there are a lot of literature within the business and management literature measuring performance. But the aim of this thesis is exploring how machines enhance the detection of weak signals and alter the process of perceiving it (filters of weak signal). And measures for measuring filters within the literature is currently not available.

There are some papers using experiments to research the impact of biases such as framing bias (Hodgkinson et al., 1999), bias of escalation of commitment (Bateman and Zeithaml, 1989), overconfidence bias (Schoemaker, 1993), and entrepreneurs' decision bias (Burmeister and Schade, 2007). A quick reading of the papers reveals that choosing a variable requires a lot of expertise on the bias. As one of the subject matter experts advised the researcher of this thesis during a panel review, 'it is advisable to have a psychology or psychiatry training for adopting experiment method for this thesis'. The researcher is not an expert in filters/biases to create robust measures nor does he have the necessary training to develop measures to robustly measure filters of weak signal. Thus, this posed a challenge for adopting experiment as a research method for this thesis.

Apart from this, there are some practical and operational issues for conducting experiment research. Since experiments are usually conducted within an organisation, this would mean enlisting the help of people or employees from the organisation. This is usually not easy (Chatterji et al., 2016) and this was the same for the researcher of this thesis. Further, due to the disruptions and lockdowns due to the COVID-19 pandemic, many of the organisations and its employees were going through a tough phase. This made enlisting employees for experiment research extremely difficult. Many experiments use students to overcome this (Harrison and List, 2004). Even though this has its own merits and demerits; using students requires access, resources, and some sort of compensation for participation (either academic credits or monetary benefits) for e.g., see: Schoemaker (1993). But the researcher of this thesis did not have the access nor the authority to conduct experiments with students. Further there were no resources available for compensating the students with either grades/credits or monetarily.

Another challenge, if experiment research was to be used, was that of isolating the variable of interest. As “[t]he real issue [in experiments] is determining the best way to isolate the causal effect of interest” (Falk and Heckman, 2009, Pg 536). Considering the remote working of all employees and students, it was not possible to control the environment remotely and thus it was not possible to isolate the cause and effect. Thus, even though experiment could be well suited for answering the research questions of this thesis, considering the above limitations, case study research was chosen.

5.3.2. Case study versus participatory research

Participatory methods such as action research, ethnography, etc., are usually preferred by researchers of the constructivist paradigm. As with experiments,

the participatory methods could be used as research methods for this research. But the reasoning for not choosing this approach is presented below. Research using these methods are generally done over a long period of time and the researcher is generally a part of what is being researched. These methods are employed to necessitate and observe change in a phenomenon. As mentioned in the previous section, due to various limitations, it was not possible for the researcher to be part of the events where the researcher planned to collect data. Further, participant research methods usually require the researcher to be able to control the behaviour of the event in study.

Thus, even though these methods could have been used to address the research herein, it was not possible for the researcher to observe the phenomena being researched for a long time. Another reason for not choosing the participatory methods was that observing a change in phenomena was not a part of what was being researched in this thesis. Further, part of the research could only be done when the project being investigated was completed which made participatory research impossible. Thus, case study was preferred over participatory methods of research.

Table 12 below, briefly summarises the comparison made above and presents Case study as the choice of method.

Table 12: Case study comparison

| Method | <i>Form of research question</i> | <i>Requires control of behavioural events?</i> | <i>Access to/ and availability of resources</i> | <i>Applied in this thesis</i> |
|----------------------|----------------------------------|--|---|-------------------------------|
| Experiment | Why? How? | Yes | No | No |
| Participation | How? Why? | Yes | No | No |
| Case study | How? Why? | No | Yes | Yes |

Chapter conclusion

This chapter has introduced the research design of this thesis. At the beginning of the chapter the philosophical stance of this research, Pragmatism, was introduced and an argument was presented for the choice of this philosophical stance. Then the methodological choice of abduction was presented along with the justification for this choice. Finally, the method of choice, its relevance, and justification was presented. The chosen method was case study method within which, the choice was for a multiple case study using multimethod research. As part of the research method and to establish its relevance to this thesis, the research questions were presented.

To summarise, this thesis takes the pragmatists view that it is important to use all the tools available to solve a problem or understand a phenomenon. Case study can accommodate various methods and has advantages over other methods when context and real-life situations have a bearing on what is being researched. Case study method is especially useful for an empirical study that "investigates a contemporary phenomenon in-depth and within its real-world context, especially when the boundaries between phenomenon and context may not be clearly evident" (Yin, 2014. Pg 16).

As Yin,2014 in Ates (2008, Pg. 94) states "an experiment intentionally divorces a phenomenon from its context, so that concentration can be focused on only a few variables" and that "the survey designer frequently struggles to limit the number of variables to be analysed and hence the number of questions that can be asked to fall safe and sound within the number of respondents that may be surveyed". Thus, case study is the reasonable choice for conducting this research. The case study will be a multi method case study and data will be collected using interviews, project

documents (workbook; Miro boards), survey, observation group, and literature.

In the next chapter, the case study design will be presented.

6. Case study design

Case study can accommodate variety of research methods. As Yin (2014. Pg 12) states "the case study's unique strength is its ability to deal with a full variety of evidence – documents, artefacts, interviews and observations – beyond what might be available in a conventional historical study". Even though case study research can accommodate variety of methods most case study research in social sciences is predominantly either qualitative or quantitative.

This thesis is pragmatic, in both senses – philosophical as well as colloquial, and attempts to explore how machines enhance the detection of weak signals and alters the process of perceiving it (filters of weak signals). This meant that there was a need to gain insight from people as well as observations. Thus, this research was designed as multimethod research.

Mixed method research is commonly referred to in research methods textbooks but not so much on multimethod. Having read the common research methods textbooks such as Easterby-Smith (2012) and multimethod book from Brewer and Hunter (2005) the author believes that multimethod is the overarching name which includes mixed methods. Multimethod can be different qualitative methods (e.g., field work and semi-structured interviews) or different quantitative methods (e.g., survey and experiment) within one research. Mixed methods are generally referred to when there is a mix of qualitative and quantitative methods within a research project.

As Brewer and Hunter (2005, Pg 63), "The multimethod strategy calls for the use of multiple methods with complementary strengths and different weaknesses in relation to a given set of research problems. But these criteria don't imply that one must always employ a mix of qualitative and quantitative methods in each project. This may sometimes be the case, but

some research problems might be better served by combining two different types of quantitative methods or of qualitative methods. In short, the multimethod strategy focuses more on the particular problem's demand than on some particular set of combination of methods".

Since different qualitative methods such as observation and semi-structured interviews have been used, this thesis will be classified as a multi-method research. Nonetheless, the argument for mixed methods also holds true for multimethod research and is included below.

Mixed methods research and multimethod research have faced scepticism from various researchers, as it was believed that the methodological assumptions were incompatible. This has changed and in fact multi methods research is gaining more traction due to the recent philosophical arguments that "the two traditions should not have a separate-but-equal status, and should instead interact" (Olsen, 2004. Pg 1). As Campbell (1975. Pg 191) states "Qualitative knowing cannot be replaced by quantitative knowing. Rather, quantitative knowing has to trust and build on the qualitative, including ordinary perception. We methodologists must achieve an applied epistemology which integrates both". Brewer and Hunter (2005, Pg 33) believe that subjecting theory to multiple methods strengthens the evidence and in turn strengthens the theory as "theories do not respect conventional methodological boundaries". In essence the application of mixed method and multimethods research broadens as well as deepens the understanding of the research problem presented (Onghena, Maes and Heyvaert, 2019). Using mixed methods and multimethod within a case study is a common method in social science research (For e.g., see: Brewer and Hunter, 2005; Heather *et al.*, 2008).

To explore if machines enhanced detection of weak signals and drivers. There was a need to compare machine output to that of human detected drivers in order to make inferences. It was important to make comparisons based on the same time frame. With respect to case study 1 (presented later), the event had already taken place and concluded. Therefore, it was not possible to make this comparison. Thus, to overcome this, a second case study (case 2, presented later) was designed. Nonetheless, it was important to investigate the opinions of participants to explore how machines would alter the process of perceiving (filters) weak signals. For this, participants were interviewed using a semi-structured interview. Further, it was important to investigate the opinions of experts with respect to the research questions laid out earlier. This was done in third phase – expert interviews which will be presented later.

In case 1 & case 2, the machine learning algorithm's output was a cluster of words which did not have any labels. The labelling of the cluster was a subjective exercise. To understand the effects of the labelling within a group setting. This led to the use of group observation.

Thus, this thesis is multimethod research using multiple case studies with the unit of analysis being scenario planning activities within the context of scenario planning projects.

For a rigorous case study research it is crucial that following are related and integrated with the case (Yin, 2006):

- i. Research questions
- ii. Units of analysis
- iii. Samples for study

- iv. Instrumentation and data collection methods
- v. Analytic strategies

Considering the importance of the above points each will be addressed individually. The research questions were identified after a thorough literature review and was presented in the literature review chapter. In the following sections, the unit of analysis and the sample for the study are presented. Data collection methods and analysis are presented in next chapter.

6.1. Unit of analysis

The unit of analysis is the “basic element of the study” that the researcher would like to “generalise” i.e., the who or the what of the study (Karen J. Long in Lewis-Beck, 2004. Pg 1157). As Easterby-Smith (2012. Pg. 65) states “The unit of analysis is the entity that forms the basis of any sample”. In the social sciences and management studies, samples can be drawn from countries, international alliances, schools, communities, interest groups, race, industrial sectors, organisations, departments, families, groups, individuals, incidents, stories, accidents, innovations etc. (Easterby-Smith, 2012) (Karen J. Long in Lewis-Beck, 2004) (Saunders, Thornhill and Lewis, 2015).

Yin (2018) suggests that unit of analysis is in essence “the case” that is being investigated. He explains that the case is dependent on the research question. For instance, the unit of analysis, based on the same data but depending on the research question, can be a country’s economy, an industry in the world marketplace, an economic policy, or the trade or capital flow between countries. Another example from Karen J. Long in Lewis-Beck

(2004) is the student scores aggregated to compare schools. Here the students are not the unit of analysis but rather the schools and the country.

To further understand the concept of unit of analysis, two PhD theses from the Strathclyde Business School were explored. The first was by Dr Aylin Ates which investigated the strategy making process in SMEs. She states that "My interest for the present study lies in understanding strategy processes empirically in an SME real life context" (Ates, 2008. Pg 100). And thus, her unit of analysis were "strategic journeys, decisions and initiatives in the investigated SMEs" (Ates, 2008. Pg 100). The other thesis was on the business model changes of early university spinoffs. Here the author very concisely states that his unit of analysis was "business models (and its constituent elements)" (Costa, 2014 Pg. 20).

Thus, it can be inferred from the above and simplified that a unit of analysis is the broader scope in which research is undertaken to answer the research question(s), but it is narrow enough to set a boundary for the investigation. In other words the unit of analysis would set the boundary of the case (Creswell, 2013). Further, Simons (2014) suggests to ask oneself what defines the boundary of the case. This could be an institution, or a unit within an institution, or people within an institution, a region, a project, a policy, etc. The unit of analysis in the context of an organisation would be, depending on the research question, network level or corporate level or business unit level or team level or individual level. To get a more intuitive understanding of unit of analysis two recent doctoral thesis from the same department to which the researcher belonged in Strathclyde business school were explored. This was done as it was easy to access the authors of the respective theses for any follow up queries.

The first thesis was by Sunner (2022) who is interested in investigating the alliance and partnership of organisations within a FinTech cluster. The unit of

analysis for his research is “the network level” within the FinTech cluster). The second thesis was by Gokmen (2022). This thesis explored the effectiveness of scenario planning in the shipping industry and thus was similar to the research field to this thesis. The unit of analysis in Gokmen (2022) was scenario teams in the early part and later shifted to scenario teams.

Based on the above, the appropriate unit of analysis for this research is “scenario planning activities” within the context of the scenario planning projects.

In the next section the sampling choice for the study will be presented.

6.2. Sample for the study

The word ‘sample’ is quite often associated with quantitative research (Bryman, 2012). Rightfully so, as the aim of quantitative research, which is generally based on the positivist philosophical view, aims for generalisation. Hence sampling is important as it must be representation of the population. Oxford English Dictionary defines sample as “a small part or quantity intended to show what the whole is like” (Pocket Oxford English Dictionary, 2013). In quantitative research, the sampling methods are usually random probabilistic and variations thereof (Bryman, 2012).

But in qualitative research, seldom the aim is generalisation or to achieve law like inferences. Thus, the traditional probabilistic random sampling is not suited. Nonprobability sampling (or non-random sampling) is more suited. The most common types of non-probability sampling are Quota, Purposive, Volunteer (snowball, self-selection), and Haphazard (convenience).

Quota is used as an alternative to random sampling when there are constraints such as costs or time. And is usually used for structured interviews as part of a survey strategy. As this research is a multi-method qualitative research, quota sampling is not a suitable technique for sampling. Volunteer and haphazard have very low credibility in terms of being a representative sample. Also, these sampling methods are used when access is extremely difficult (e.g., research on prostitutes). Thus, these sampling techniques are not suited for this research. Purposive sampling, depending on the sample type used (such as sample being heterogeneous or homogeneous), the likelihood of sample being representative varies from generally low to, depending on the researcher's choices, reasonable. (Saunders, Thornhill and Lewis, 2015)

Table 13 below shows the various factors and choices of non-probability sampling techniques.

Table 13: Choice factors for non-probability sampling techniques

| Group | Technique | Likelihood of sample being representative | Types of research in which useful | Relative costs | Control over sample contents |
|------------------|--------------|--|--|-------------------------------|------------------------------------|
| Quota | Quota | Reasonable to high, although dependent on selection of quota variables | Where costs constrained or data needed very quickly so an alternative to probability sampling needed | Moderately high to reasonable | Specifies quota selection criteria |
| Purposive | Extreme case | Low | Unusual or special | Reasonable | Specific selection criteria |

| | | | | | |
|------------------|----------------|---|--|------------|--------------------------------|
| | Heterogeneous | Low, although dependent on selection of quota variables | Reveal/illuminate key themes | Reasonable | Specific selection criteria |
| | Homogeneous | Low | In-depth focus | Reasonable | Specific selection criteria |
| | Critical case | Low | Importance | Reasonable | Specific selection criteria |
| | Typical | Low, although dependent on selection of quota variables | Illustrative | Reasonable | Specific selection criteria |
| | Theoretical | Low | Inform emerging theory | Reasonable | Specific selection criteria |
| Volunteer | Snowball | Low, but cases likely to have characteristics desired | Where cases difficult to identify | Reasonable | Selects initial participant |
| | Self-selection | Low, as cases self-selected | Where access difficult, research exploratory | Reasonable | Offers only general invitation |
| Haphazard | Convenience | Very low (often lacks credibility) | Ease of access | Low | Haphazard |

Source: Adapted from Saunders, Thornhill and Lewis (2015, Pg 298)

Considering the factors shown in the above table, the best suited sampling technique for this research is purposive sampling. In general the “discussions on sampling in qualitative research tend to revolve around the notion of purposive sampling” (Bryman, 2012, Pg 416). Purposive sampling is driven by the research question (or objective) and the judgement of the researcher. Purposive sampling is generally used when working with small samples such as case studies (Saunders, Thornhill and Lewis, 2015) and when the cases are informative and exploratory (Neuman, 2014). Simply put, as Bryman (2012, Pg 419) states “The goal of purposive sampling is to sample cases/participants in a strategic way, so that those sampled are relevant to the research questions that are being posed”.

From the table 13 above, this research will be based on purposive sampling. The research objective and research questions of this research have been discussed critically in the literature review chapters. Based on this, this thesis can be deemed as an exploratory research, which is in line with use of the purposive sampling technique. Though the aim of qualitative research is not generalisation (Braun and Clarke, 2013), nonetheless, to maintain rigour, a heterogenous sample technique within purposive sampling was chosen. Based on the research questions, the case study samples included both participants who scanned for weak signals as part of scenario planning. And experts in scenario planning who have facilitated scenario planning projects. The details of the cases and research participants will be presented in the following chapters. The participant profile is presented in table 14 below.

Table 14: Sample heterogeneity

| Heterogeneity | |
|----------------------|--|
| Case | Participants profile |
| Case 1 | University Alumni (Working professionals), MBA students, Academic staff, and Professional University staff |
| | PhD students - observation |
| Case 2 | International MBA students - Various locations |
| Expert interviews | Leading international experts - Professional and academics |

Judgment of the researcher is an integral aspect of purposive sampling. The researcher of this thesis has undergone formal and intense training in research methodologies and various methods. Along with this the researcher, by the virtue of association with academics along with the guidance of his supervisors, gained hands on insights which contributed to his knowledge. Apart from this, the researcher has a professional experience of more than

10 years. This experience has given the researcher the maturity to make good judgement. Table 15 below summaries the alignment of this sampling design with factors of purposive sampling.

Table 15 :Purposive sampling criteria satisfaction

| Purposive sampling Criteria | |
|---|-----|
| Is the sample representative of the population? | No |
| Will the samples be driven by research objective? | Yes |
| Will the cases be exploratory? | Yes |
| Will the cases be informative? | Yes |
| Will the samples be heterogeneous? | Yes |
| Will the resources available to the researcher be low but reasonable? | Yes |

As mentioned earlier, for a rigorous case study research it is crucial that following are related and integrated with the case (Yin, 2006):

- i. Research questions
- ii. Units of analysis
- iii. Samples for study
- iv. Instrumentation and data collection methods
- v. Analytic strategies

The research question was presented in the literature review chapter. The unit of analysis and the samples for the study were presented above. The remaining two aspects, instrumentation and data collection methods, and analytic strategies will be addressed as a separate chapter. As this thesis uses multi method research, each method needs deeper analysis and clarification of choice. Thus, the next chapter is dedicated to data collection methods and analytical strategies with respect to each case study.

Chapter Summary

As mentioned earlier, for a rigorous case study research it is crucial that following are related and integrated with the case: i. Research questions: This was presented in the literature review chapter, ii. Unit of analysis: This was presented in this chapter, iii. Samples for the study: Presented in this chapter. In the next chapter each case is introduced along with the respective method of data collection.

7. Introduction to the case studies

In the previous chapters, the philosophical and methodological choices were presented. In this chapter the three case studies along with the data collection and analysis methods for the respective case study will be presented. Figure 17 represents the three cases along with the data collection methods used. The data for this thesis was collected over a period of three years – 2021, 2022, and 2023. This is represented by the three blue circles in figure 17. Above the blue circle, the cases are mentioned respective to the year the data was collected. Below the blue circle, the data collection methods for the respective cases are mentioned. The machine learning model used is common for case 1 and case 2.

As this is a multi method research, for the ease of reading, figure 17 is repeated throughout this chapter and the relevant aspects presented is highlighted in yellow in the figure.

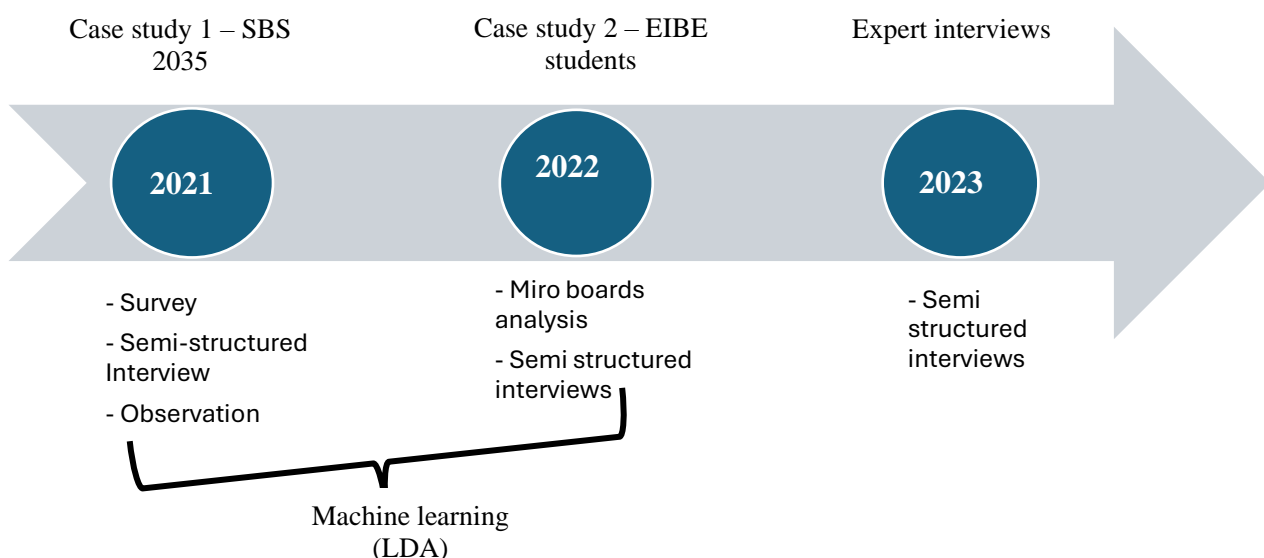


Figure 17: Case study and respective data collection methods

Table 16 below summarises the total data collected from various methods. A total of 27 interviews, 1 group observation (5 participants), and 13 Miro boards were analysed as part of this thesis.

Table 16: Data collection quantity description

| Data collection quantity description | | | |
|--------------------------------------|----------------------------|-----------------------------|-------------|
| | Semi-structured interviews | Observation (group) | Miro boards |
| Case 1 | 9 | 1 group with 5 participants | - |
| Case 2 | 3 | - | 12 |
| Expert interviews | 15 | - | - |
| Total | 27 | 1 | 12 |

7.1. Case study 1 – SBS 2035

The scenario planning project, SBS 2035, was initiated by the Dean of the Business School, Professor David Hillier, in April 2020. The team was selected by the Dean on the basis of a balanced representation between academic staff from across the school's disciplines and administrative support staff.

In the below figure 17 case study 1 is highlighted in yellow. In this section the case study will be introduced, and the data collection method will be presented.

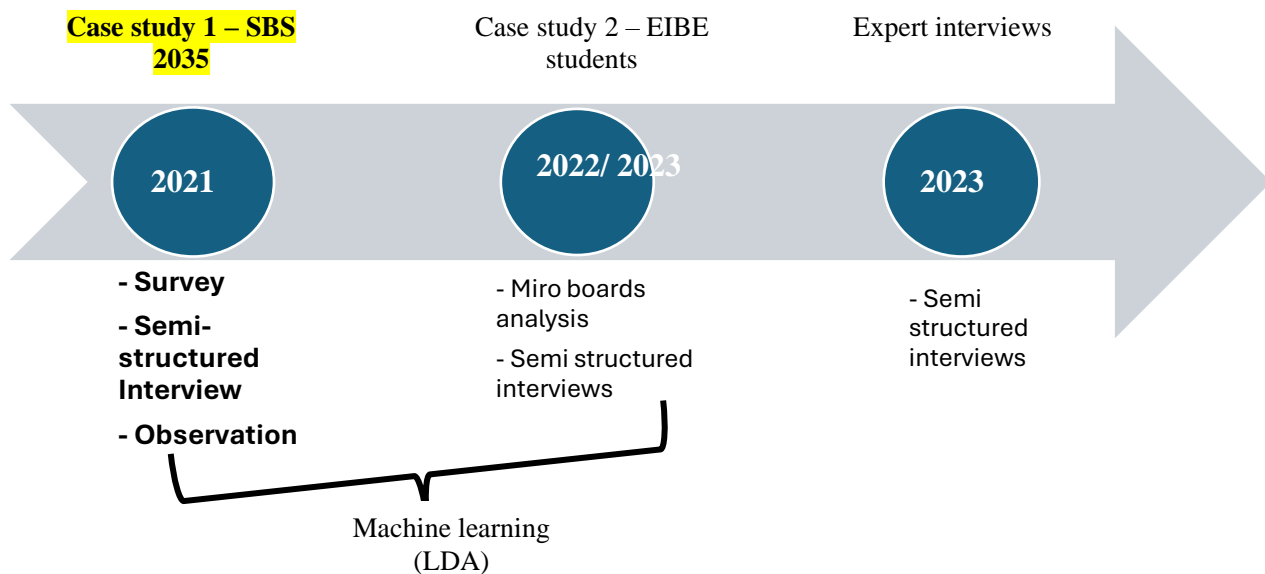


Figure 17: Case study and respective data collection methods

Professor Dr Peter McKiernan led the team along with Professor Dr George Wright. Both of them are senior academics and leading strategic foresight experts with substantial track records in the field. In turn, they selected a team consisting of Business School alumni, other academics, MBA students, PhDs, and administrative staff. The alumni were working in Switzerland, and all of them were conversant with foresight work from their experience in the MBA programme at Strathclyde. In the last stage, a team of then studying MBA students (class of 2020) performed a final analysis and checking. All the team members, at all stages, were volunteers. SBS 2035 was an intuitive logics scenario planning project for understanding the future of management education in the year 2035 and the role that a business school will have in that future. The whole project was conducted virtually using zoom and Miro boards.

Table 17: Participant list, SBS 2035

| Name | Position | Role in SBS 2035 project |
|-------------|--|---------------------------------|
| Person 1 | Professor (HCE) | Lead |
| Person 2 | Professor (Management Science) | Co-Lead |
| Person 3 | Senior Teaching Fellow (International Centre UAE) | SME |
| Person 4 | Business School adjunct, Greece | SME |
| Person 5 | Professor (HCE) | Advisor/Volunteer |
| Person 6 | Strategic Investor Relations Manager | Advisor/Volunteer |
| Person 7 | Professor (Management Science) | Advisor/Volunteer |
| Person 8 | Director GCC, Strathclyde Business School | SME |
| Person 9 | Professor (Management Science) | Advisor/Volunteer |
| Person 10 | Director of Undergraduate Studies (HCE) | Advisor/Volunteer |
| Person 11 | Faculty Officer (Strategic Projects) | Advisor/Volunteer |
| Person 12 | Assistant Faculty Officer (Strategic Projects) | Advisor/Volunteer |
| Person 13 | Swiss Alumni | Experienced Volunteer |
| Person 14 | Swiss Alumni | Experienced Volunteer |
| Person 15 | Swiss Alumni | Experienced Volunteer |
| Person 16 | Swiss Alumni | Experienced Volunteer |
| Person 17 | MBA student | Experienced Volunteer |

| | | |
|-----------|---------------------------|-----------------------|
| Person 18 | MBA student | Experienced Volunteer |
| Person 19 | MBA student | Experienced Volunteer |
| Person 20 | Doctoral Researcher (HCE) | Experienced Volunteer |
| Person 21 | Doctoral Researcher (HCE) | Experienced Volunteer |

Source: Borrowed from project documents with permission from the Dean.

Note: SME = Subject Matter Expert

It should be noted that Prof McKiernan is one of the supervisors of the researcher. This has no conflict of interest or influence on the outcome of the research. To ensure this, Prof McKiernan was excluded from the interview pool. It should also be noted that the researcher was part of the project and participated in the project for information gathering, making observations, and in creating the slide deck for reporting purposes. But the researcher did not participate in the detection of WS, drivers of change, or trends from the workbook, nor was the researcher involved in the development of the scenarios. Thus, assuring that the researcher thoughts or inherent biases did not affect the case.

The data for the project was collected by volunteers using various resources such as web search (mainly using Google search engine), academic literature, and practice-based article search. The collected data was then distributed amongst the team members for studying the source in full. A workbook was created with relevant coding sections where the team members could update their thoughts. The workbook was an electronic workbook in the MS-Excel format and had multiple roles. Firstly, it would act as a reference and information record document. Secondly the workbook would prevent duplication of information. Thirdly it would help in the identification of drivers of change that would be used to develop scenarios.

The workbook had a worksheet with categories and subcategories. The categories were based on the STIRDEEPER (Society, Technology, Industry, Resources, Demographics, Economics, Environment, Politics, Energy, Religion) framework and each sub-category was a cluster. The team members, with their best knowledge, would update the information they discovered under the relevant sub-category. The workbook was used by the Swiss alumni to identify the drivers of change and key drivers. This was facilitated virtually by the Business School adjunct in Greece. Due to the restrictive time schedules of the Swiss alumni, some of the volunteers could not follow through till the end. Thus, the task of driver identification and analysis was taken up by MBA students with guidance from Professor Dr McKiernan and Professor Dr Wright. The MBA students along with other members of the team, except the Swiss alumni and the researcher of this thesis, were involved in the development of the scenarios including the narratives planning. Table 18 below shows an extract of the workbook that was used in the project and a more substantiative version of the workbook is attached in the appendix. Due to the sheer size of the workbook, it was impractical to attach the whole workbook in the appendix. Thus, a practical length sample of the workbook has been attached in the appendix.

Table 18: Workbook sample

| Coding | | | | |
|------------------------------|---|---|------|--|
| Category | Subcategory | Source | Page | Description |
| 1. Social Environment | 1.1. Demand of higher education increases in 2030 | (Higher Education Policy Institute, 2020C) Nick Hillman | Blog | One reason why that would be so challenging is the extra demand that is about to arise as a result of the coming increase in the number of 18-year olds, continued growth in the proportion of young people who want to reach higher education and better outcomes in schools. At HEPI, we have calculated that we could need another 300,000 higher education places by 2030. |

| | | | | |
|--|--|--|------|---|
| | | (Higher Education Policy Institute, 2020C) Nick Hillman | Blog | Argues that student numbers should remain uncapped, in contrast to trends in other countries, and participation should widen. Draws out the implications of this widening participation on provision. |
|--|--|--|------|---|

The data was collected using survey, semi-structured interview, and observation. In the following sections, the various methods of data collection will be presented.

7.1.1. Primary data collection method – Survey

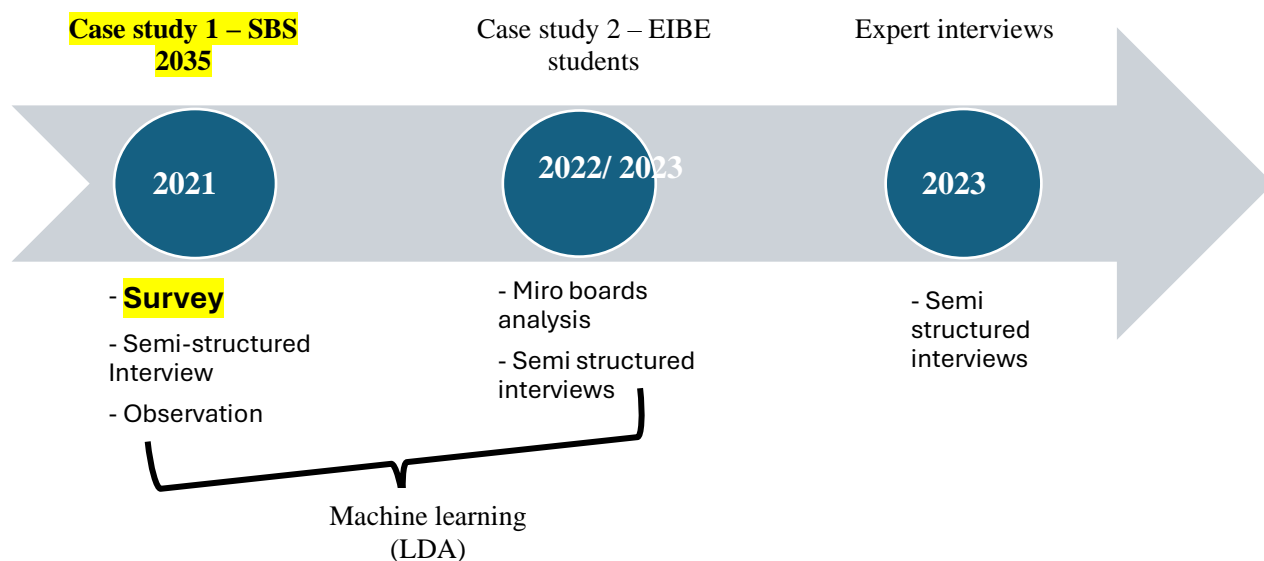


Figure 17: Case study and respective data collection methods

The main data collection methods used for this research were semi-structured interviews and participant/digital artefact observation. But due to the practical limitation of time that participants can offer, the researcher

decided to send a survey to capture the participants' opinion before the interview and use the interview itself to explore deeper on the research questions. The survey was sent to all the participants of the SBS 2035 project. A total of 15 responses were received out of a total of 21 participants. This put the response rate at 71%. The survey questionnaire is attached in the appendix.

The aim of survey was to collect the opinions of the participants on filters and the use of machine learning for detecting weak signals during scenario planning. The survey was not designed for deploying quantitative analysis but rather to capture opinion of the project participants using descriptive statistics.

The design of a survey is an extremely important step and can be equated to the foundation of a building – if the foundation is strong, the building will be strong too and if the foundation is weak so will be the building. Having read research methods books e.g., Easterby-Smith (2012), Bryman (2012), and Saunders, Thornhill and Lewis (2015), the researcher was well aware of the steps needed to develop a good survey. With the author's own experience, he knew that by keeping the survey short he could get more responses. The common steps suggested by the research methods for designing surveys are:

- Develop good questions using the right language.
- Test the survey, get the feedback, and improve the survey.
- Use network and/or rewards to maximise the response rate.

For the first step, that is develop a good survey with a good language, the researcher used the guidelines of two main books - Payne (1965) The art of asking questions and Oppenheim (1992) Questionnaire design, interviewing, and attitude measurement. The book by Payne was extensively referred as it

had abundant examples on various issues while designing a question. The questions were designed for receiving Likert scale responses.

The researcher, based on a decade of work experience, knew that simple statements that communicate the essence of a question were more appealing to the participant rather than long factual statements. For e.g., to capture power filter the researcher designed this statement "When people encounter an event whose occurrence is so implausible, they hesitate to report it fearing they will not be believed". The survey was designed to be delivered and used electronically.

Once the design was completed, the survey was tested on eleven PhD students who were colleagues of the researcher. The PhD students were well versed with research methodologies and were chosen as they could give critical and in-depth feedback on the design. The details of the PhD students are presented in table 20. The feedback from the PhD students were collected and the survey was updated and finalised accordingly. Qualtrics survey platform provided by the Strathclyde business school was chosen as the platform for administering the survey.

Table 19: Pilot survey participants

| Anonymised name | Role | Department | Year of PhD study |
|------------------------|-------------|----------------------|--------------------------|
| Person 1 | PhD Student | Management Science | Year 3 |
| Person 2 | PhD Student | Strategic Management | Year 3 |
| Person 3 | PhD Student | Operations Research | Year 3 |
| Person 4 | PhD Student | Operations Research | Year 3 |
| Person 5 | PhD Student | Operations Research | Year 3 |
| Person 6 | PhD Student | Entrepreneurship | Year 2 |
| Person 7 | PhD Student | Entrepreneurship | Year 2 |
| Person 8 | PhD Student | Entrepreneurship | Year 2 |

| | | | |
|-----------|-------------|----------------------|--------|
| Person 9 | PhD Student | Entrepreneurship | Year 3 |
| Person 10 | PhD Student | Entrepreneurship | Year 3 |
| Person 11 | PhD Student | Strategic Management | Year 1 |

The final step was to send the survey and receive the maximum response from the SBS 2035 participants. With the researcher's previous experience, it was known to him that a letter from a higher authority would garner more responses. Thus, with the support of the researcher's supervisors, the researcher requested the Dean of the Business School to send a letter to the participants of SBS 2035 in support of this research. The dean very kindly agreed and the approval email has been attached in the appendix.

The researcher found that it was only fair to reward the participants as most of them were busy working professionals and academics with no obligation whatsoever to support. There is no consensus on whether it is correct to reward survey and interview participants within the academic research community. There are arguments for and against the rewards. The main concern is that it should not tempt the participants as this would affect the quality of the sample. By keeping the value of the reward to a meaningfully small amount, somewhere between £10 – 25, the concern of tempt can be avoided.

Also, the target participants were from established professional and academic backgrounds, who would not be tempted for a small reward payment. But, rather, would appreciate the gesture of thank you of the researcher. As mentioned by Braun and Clarke (2013, Pg. 61) "participants do offer up their time, and may have costs associated with participation (such as travel and childcare), and the time research takes. Offering some form of 'thank you' takes this into account".

Thus, the researcher decided to offer a reward to those who participated in the survey AND the interview. The supervisors of the researcher agreed to fund the reward from their research fund. The reward was in the form of £25 amazon vouchers. Even though 11 participants were eligible for the vouchers, it should be noted that three participants did not accept the voucher as they said they wanted to support the researcher. Thus, a total of 8 amazon vouchers worth £25 each were distributed bringing the total amount spent on the vouchers to £200. Another two participants informed the researcher that they used the voucher to donate to a food bank. The survey findings are presented in the next chapter.

7.1.2. Primary data collection method – Semi structured interviews

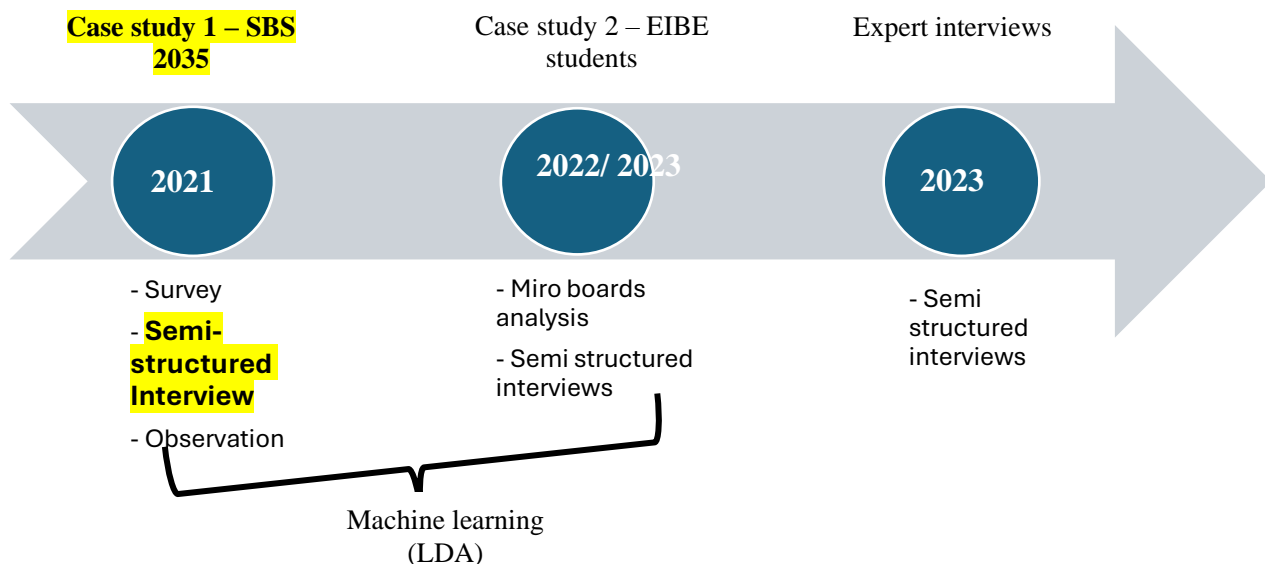


Figure 17: Case study and respective data collection methods

The participants of the SBS 2035 were invited to take part in an interview with the researcher. The interview participants profile is presented in table 20. A total of nine participants agreed to take part in the interview. All interviews were held electronically over Zoom and were recorded. Before recording the interview, the participants were informed of their rights and their consents were taken before recording as per the university's ethics guidelines.

Table 20: Semi-structured interviewee profile

| Interviewee | Location | Profile | SP experience | Association | Interview date |
|--------------------|-----------------|--------------------|----------------------|--------------------|-----------------------|
| Person 1 | Virtual (Zoom) | Academic / Prof | SME | SBS - Retired | 10/08/2021 |
| Person 2 | Virtual (Zoom) | MBA/ professional | some exposure | SBS Alumni | 11/08/2021 |
| Person 3 | Virtual (Zoom) | Academic / Prof | some exposure | SBS Alumni | 11/08/2021 |
| Person 4 | Virtual (Zoom) | MBA/ professional | some exposure | SBS Alumni | 13/08/2021 |
| Person 5 | Virtual (Zoom) | Professional | No experience | SBS | 16/08/2021 |
| Person 6 | Virtual (Zoom) | Project Management | No experience | SBS | 18/08/2021 |
| Person 7 | Virtual (Zoom) | Academic / Prof | No experience | SBS | 24/08/2021 |
| Person 8 | Virtual (Zoom) | Academic / Prof | SME | SBS | 27/08/2021 |
| Person 9 | Virtual (Zoom) | MBA/ professional | some exposure | SBS Alumni | 07/09/2021 |

One of the advantages with Zoom is that it automatically generates a transcript based on the recording. But the automatically generated transcripts have errors. The researcher used this feature to generate the transcript but made sure that all the errors were rectified. This was done by thorough reading and by making necessary corrections by hearing the voice recording accordingly.

A qualitative semi-structured interview is a conversation rather than question and answer session. It is important that the focus of the interview is not carried away by conversation. To conduct a good interview Yin (2014, Pg 123) suggests that the interviewer should develop or have the following skills:

- Ask good questions—and interpret the answers fairly.
- Be a good “listener” not trapped by existing ideologies or preconceptions.
- Stay adaptive, so that newly encountered situations can be seen as opportunities, not threats.
- Have a firm grasp of the issues being studied, even when in an exploratory mode.
- Avoid biases by being sensitive to contrary evidence, also knowing how to conduct research ethically.

The researcher possessed these skills by actively developing them through formal research training as well as by speaking to his informal research network. Thus, as recommended, the researcher prepared an interview guide to conduct the interview. The guide consisted of questions that would help in ensuring that everything that the researcher wanted to cover was covered and if the conversation digressed then it would be easy to come

back on track. It should be noted that this was not a structured interview. The interview was semi-structured in nature and the researcher would amend and exclude questions depending on the circumstances. As part of the interview an illustrative depiction of the research framework was shown. This was done in order to set the context of the research to allow in establishing a focussed approach. As well-defined context allows for the collection of rich and relevant data. The ML output was also shown to the interviewees to give them an insight into what the output looks like. The ML output was also shown to the participants to set the context and is attached in the appendices.

This guide was then tested by conducting two pilot interviews. One was with an active participant in the SBS 2035 project, and the other was a PhD student with research expertise in scenario planning. Based on the feedback from the pilot interviews, the researcher updated the interview guide. The interviews of the SBS 2035 participants were designed so that the interviews lasted no more than one hour. The interview protocol is attached in the appendices (interview protocol, case 1).

7.1.3. Primary data collection method – Participant observation

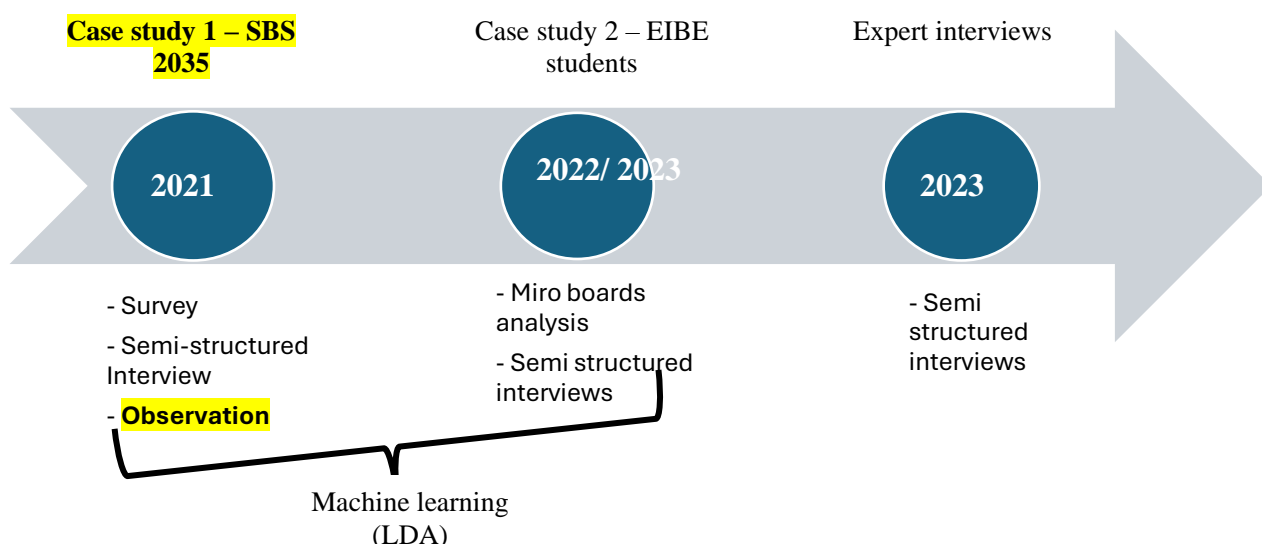


Figure 17: Case study and respective data collection methods

Participant observation is a method in which the researcher immerses themselves in a group to observe behaviour, to listen to conversations, and ask questions (Bryman, 2012). This is very similar to ethnographic research, and as Bryman (2012, Pg. 432) states “many definitions of ethnography and participant observation are very difficult to distinguish”. But the term ethnography generally has additional meaning, it is generally “a method of research and the written product of that research” Bryman (2012, Pg. 432). But in the context of this thesis, as presented earlier, the research method is not just based on observation which would have then made it ethnographic research. Rather, the research method of this thesis is mixed-method research.

The common roles that a researcher can take when conducting observations are complete participants, participant-as-observer, observer-as-participant,

and complete observer. Below are the overview of each type of observation as stated by Easterby-Smith (2012, Pg. 142).

- Complete observer: Researcher maintains distance to the object and context and avoids all direct engagement.
- Observer-as-participant: Researcher engages with the field in a relatively passive manner, e.g., by asking questions, while trying not to influence the field under study.
- Participant-as-observer: Researcher does not conceal the intention of observation and participates in the context as researcher and participant. This is the most common type of participant observation in management and business studies.
- Complete participant: Researcher conceals the intention to study and adopts more fully the role of a participant when observing the field.

Bryman (2012, Pg. 442) further distinguishes observer-as-participant as partially participating observer and minimally participating observer.

Minimally participating observer “observes but participates minimally in group’s core activities”. Thus, for this research the researcher assumed the role of Minimally participating observer. The reason for this decision was that, based on the context, it was not possible to conceal the identity of the researcher for adopting a complete observer stance. At the same time, the researcher had to limit the participation as he did not want to influence the group with the prior knowledge, he was exposed to during SBS 2035. The researcher only spoke to explain the process and to ask some probing questions at the end of the observation to collect qualitative data.

The participant observation research was conducted to understand the effects of filters of weak signals during the labelling of machine learning

output. The participants also allowed the opportunity to explore the advantages and disadvantages of machine learning in this context.

Five participants agreed to participate in this research. All of them were PhD students from the business school. All the participants, except one, did not have prior knowledge of scenario planning. They were selected this way to reduce the effect of any biases which might have been inherently present with the researchers from the scenario planning field. The exception participant was selected to help others in case of any clarifications about scenario planning from other participants.

Due to time limitations and the focus of the research, only the drivers (machine learning output) were labelled. As per the definition of observation (Saunders, Thornhill and Lewis, 2015), the researcher's activity was to analyse and interpret participant's behaviour by making notes and descriptions of the participants interactions. Due to COVID-19 restrictions, the activity was carried out online using "zoom" and "miro". The whole interactions of the participants were recorded and transcribed. Once the labelling process was complete the researcher had the opportunity to seek reflections from the participants.

The analysis from the survey, semi-structured interviews, and observations were presented to a review panel within the business school which included a subject matter expert. The panel and the researcher agreed that the researcher had to collect more data as there was a considerable time lag between the machine learning output and the time when the case study took place. This time lag could have an adverse impact while making comparisons between the human gathered drivers and machine detected drivers. Thus, the researcher collected additional data which was the Phase 2 data collection phase which will be presented in the next section.

7.2. Case study 2 – EIBE students

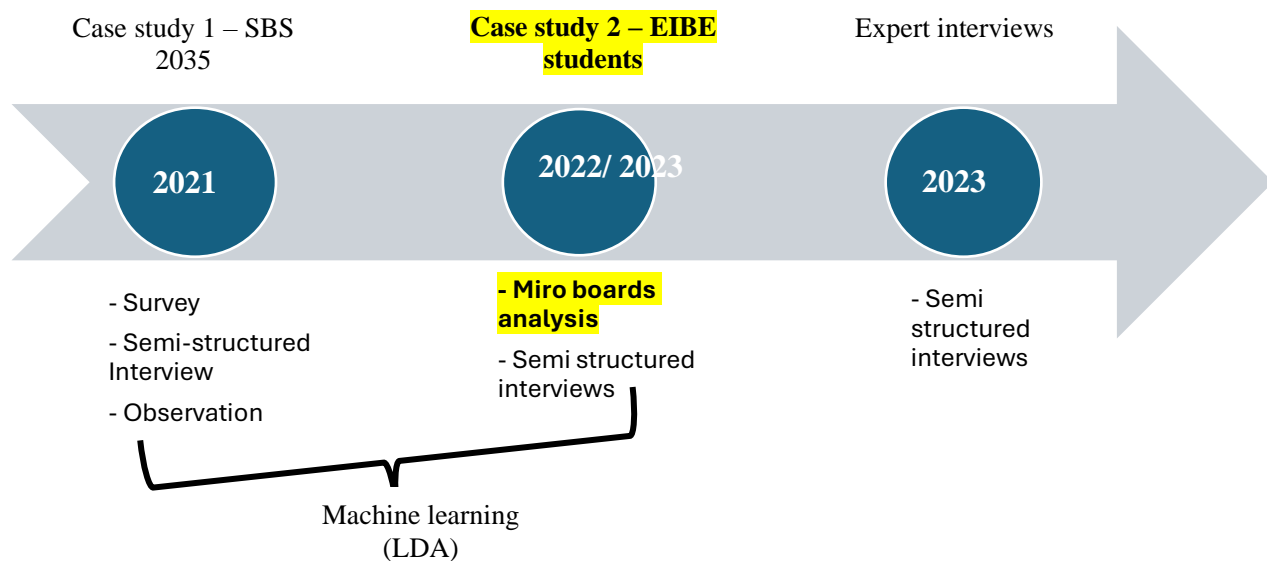


Figure 17: Case study and respective data collection methods

'Exploring the International Business Environment' (EIBE) is a course taught to the MBA students at Strathclyde Business School. In this course the students learn about scenario planning by actually doing scenario planning. The students from a cohort are split into groups. These groups then choose one country respectively from a list of six countries – Argentina, Bolivia, Chile, Paraguay, Peru, and Uruguay. Based on the country of choice, the groups need to develop scenarios for addressing 'How will the particular country selected develop over the next 15 years?'.

The students go through the intuitive logics scenario planning exercise as outlined in previous chapters. They begin with the search for drivers

(including weak signals), classify them based on STIRDEEPER, analyse these clusters, and come up with the driving forces. Based on the driving forces, the students come up with the scenarios and the respective narrative for the scenarios.

The course is split into two iterations. The first iteration is ungraded and is supported and guided by the course leader. The aim of iteration one is for students to get a feel and learn about scenario planning. Iteration two is a graded version where the students put to practice what they have learnt.

7.2.1. Data analysis process – Miro board

The EIBE course delivery is slightly different based on the type of MBA – Full time or Part time or executive. For this thesis, the EIBE course for executive MBA students was considered. The students used “Miro” digital boards² for this course. Table 21 shows the details of the Miro boards used for this thesis. As mentioned earlier, the samples chosen were based on convenience sampling. Table 22 shows the number of samples for each EIBE case. The researcher sought permission from students to access the boards for analysis. To understand and gain first-hand experience of the delivery of the course, the researcher participated as a silent observer, with permission from the course leader, Professor Peter McKiernan, and the students. The Miro boards allowed for a comparison of drivers detected by students with that of machine learning output within the same time period. This was important as it would help in addressing the second research question as outlined earlier.

Table 21: Miro boards accessed details

² <https://miro.com/>

| Group name or Miro board name | SBS executive centre | No. of people in group | SP target country | Year of the EIBE class | Miro boards accessed |
|---|-----------------------------|-------------------------------|--------------------------|-------------------------------|-----------------------------|
| Dubai 3 Argentina Iteration 2 | Dubai | 4 | Argentina | First half 2022 | Jun-22 |
| EIBE Group 4 Iteration 2 | NA | 5 | Argentina | First half 2022 | Mar-22 |
| Group 4 EIBE Iteration 2 | NA | NA | Bolivia | First half 2022 | Mar-22 |
| Iteration 2 (Bolivia) | NA | NA | Bolivia | First half 2022 | Mar-22 |
| Dubai 1 Chile | Dubai | 6 | Chile | First half 2022 | May-22 |
| G6 Chile | NA | 6 | Chile | First half 2022 | Jun-22 |
| Group A - CHILE | NA | NA | Chile | First half 2022 | Mar-22 |
| Iteration 2_Chile | NA | 6 | Chile | First half 2022 | Mar-22 |
| Dubai 2 Paraguay | Dubai | NA | Paraguay | First half 2022 | May-22 |
| EIBE Group 3 - Iteration 2 (Paraguay) | NA | 6 | Paraguay | First half 2022 | Mar-22 |
| Final Submission - Dubai 4 Peru - MG920 | Dubai | NA | Peru | First half 2022 | May-22 |
| PERU_2nd Iteration | NA | NA | Peru | First half 2022 | Mar-22 |

| | | | | | |
|-----------------|-------|---|---------|--------------------|--------|
| Dubai 2 Uruguay | Dubai | 5 | Uruguay | First half 2022 | Jun-22 |
|-----------------|-------|---|---------|--------------------|--------|

Table 22: EIBE samples

| EIBE target country | No. of boards |
|----------------------------|----------------------|
| Argentina | 2 |
| Bolivia | 2 |
| Chile | 3 |
| Paraguay | 2 |
| Peru | 2 |
| Uruguay | 1 |
| Total Boards | 12 |

7.2.2. Semi structured interviews

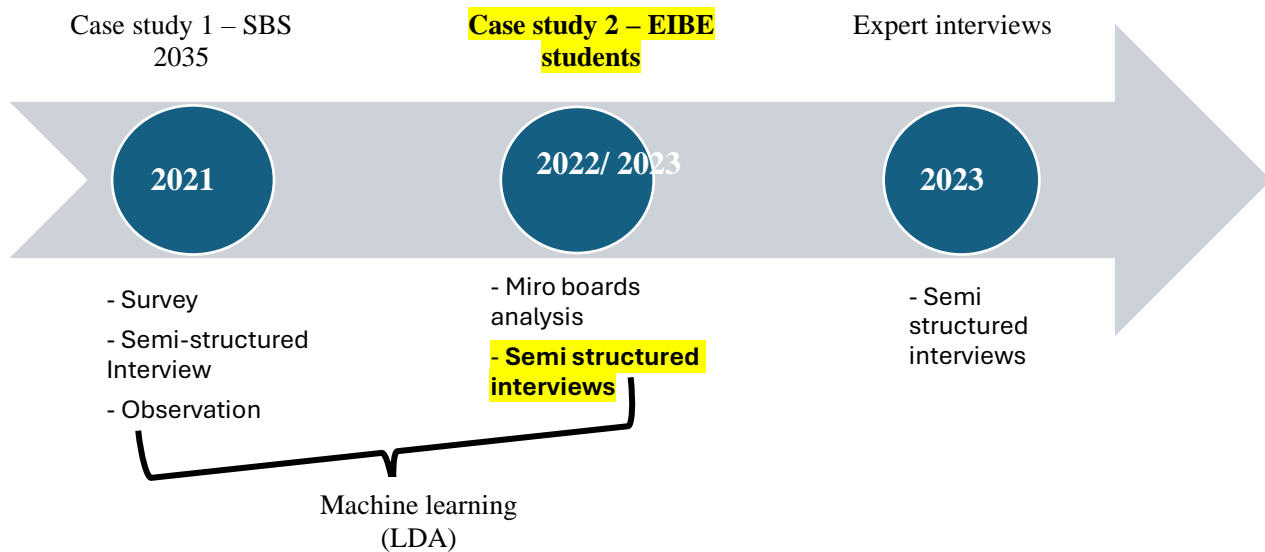


Figure 17: Case study and respective data collection methods

The interview design for the EIBE students was different from that of case study – SBS 2035 interviewees. Since the EIBE students were not part of SBS 2035, some of the questions from the interview protocol were not applicable to these students. Thus, the semi-structured interview was tailored to enquiry about the research aims of this thesis. Due to this tailoring, the interviews lasted between 20 minutes to 30 minutes.

Further the EIBE students were all working executives. Most of the students were extremely busy juggling between fulltime jobs and their MBA and thus would be put off from one-hour typical interviews. Therefore, the questions were focused on the student's opinion of using machine learning for driver and weak signal detection. For this a sample output of the machine learning was shown to them. And next data collection focused on the student's opinion on the labelling process.

Similar to the interviews of SBS 2035 participants, the interviews with EIBE students were also conducted virtually via Zoom. Only three students agreed for an interview. The participants were informed of their rights and their consent was taken before recording the interviews. The transcripts which were generated automatically by zoom, were checked for errors and necessary corrections were made. The analysis from the interviews is presented in the next chapter.

7.3. Machine learning – Case 1 and Case 2

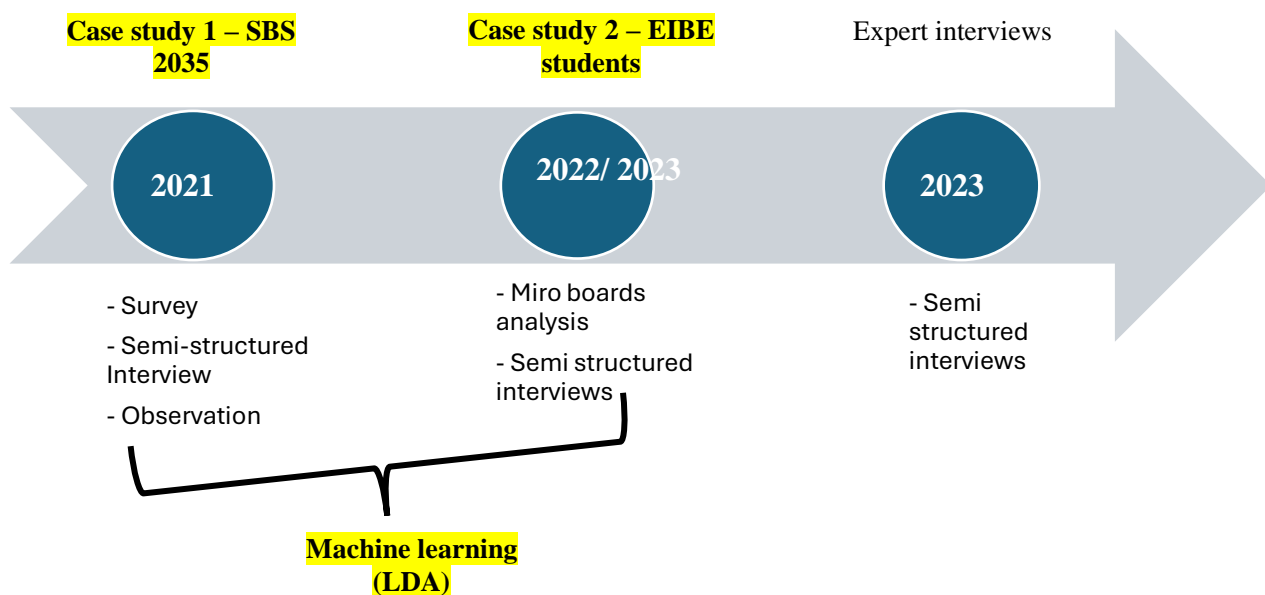


Figure 17: Case study and respective data collection methods

The field of machine learning is vast but typically the algorithms are classified as supervised, unsupervised, and reinforcement learning. The

application of machine learning is vast and is currently applied in various fields, such as fraud detection, medicine, image classification, natural language process, text analysis, etc. For this thesis, the natural language processing technique of machine learning was used to identify weak signals and drivers. Within the NLP techniques, topic modelling (LDA – Latent Dirichlet Allocation) was used. LDA is one of the most commonly used algorithms when topic modelling method is employed. This is evident as the LDA paper published has been cited 45,587 times till date (as per google scholar data accessed on 07/01/2023). For the use of LDA in weak signal detection see: El Akrouchi, Benbrahim and Kassou (2021)

The common steps in NLP are text collection, text processing, text manipulation, and then deploying the machine learning model. The first step, text collection, consisted of gathering the data from sources such as twitter, academic papers, and websites. The collected textual data is manipulated to prepare it for feeding it to the LDA algorithm. And the last step is running the algorithm. Each of the steps are presented in detail in the below sections.

7.3.1. Computer programming language – Python3

A computer programming language is a high-level programming which is used for writing instruction to the computer. Examples are for performing machine language operations and text manipulation, where the computer needs to be instructed in a precise manner. This passing of instructions using high-level programming language is called coding or **programming**, the set of instructions (algorithm) is called the **source code**, and the language used for coding is called the **programming language**. The most common languages are Java, **Python**, and C.

But the computer (CPU) cannot understand the source code as is. The source code has to be converted to something called **object code** for the computer to understand. This is done by a **translator** (another programme). For the process of translating the source code to object code, a **compiler** is used.

An in-depth discussion on the various methods of translating, coding, compiling is beyond the scope of thesis. A simplified version is presented above to give readers from non-IT background, an introduction and background to the programming language. For more information refer: Hemmendinger (2002); website:

<https://www.bbc.co.uk/bitesize/guides/zmthsrd/revision/1>

There are many programming languages, each with its own advantages and disadvantages as well as uses. Programming languages were developed with specific objectives in mind. For example, BASIC (Beginner's All-purpose Symbolic Instruction Code) was developed by John G. Kemeny and Thomas E. Kurtz at Dartmouth College in the mid 1960s (Britannica, 2021) for education. Another popular language is C. It is an algorithmic programming language.

Another type of programming language is object-oriented programming language. The popular object-oriented languages are **Python, Java, and R**. Object oriented programming languages package the data and operations in such a manner that the internal data and data structures are hidden from the programmer and only the operations are visible. This makes large scale programming easy. Also the objects can be imported from general objects to inherit their capabilities (Hemmendinger, 2002).

In this thesis the programming language used is python 3. Python is an open-source programming language and has a wide community of users and developers. Due to the open environment, there are a lot of libraries (general

objects) which can be used to perform special operations. The libraries are open source as well and usually maintained by contributors from around the world. Python has a good community of developers for machine learning algorithms. For example, see: Scikit-learn (<https://scikit-learn.org/stable/>) which has multiple libraries supporting various machine learning algorithms or Gensim (<https://radimrehurek.com/gensim/>) which specialises in topic modelling algorithms. The advantage of using libraries is that there is no need to re-invent the wheel by writing a programme for the algorithm. The right libraries have to be imported and executed in order to run the machine learning algorithm.

In this thesis, libraries are extensively used in various steps of the machine learning process. For example, 'pandas' is used to manipulate .csv files. Comma Separated Value (csv) is a standard tabulation format where a comma separates the value. The display of a csv file is similar to an excel file. Another file format used is .txt which is nothing but a file containing unformatted text.

7.3.2. Sources of data

The sources of data used for the case studies is mentioned in table 23. As it can be seen the sources of data varied slightly between the cases. In the following sections a deeper discussion is presented for each source of data.

Table 23: ML data sources

| Source | SBS 2035 | EIBE MBA (for each respective countries) |
|-----------------|----------|--|
| Academic papers | YES | YES |
| Twitter | YES | YES |

| | | |
|---|-----|-----|
| Media cloud | YES | NO |
| google search links manual | YES | NO |
| google search links automated (apify.com) | NO | YES |

7.3.2.1. Academic papers

The academic papers were collected by searching using the Scopus database as it has a wide range of journal collection. Even though programmable text mining using website interfaces was possible, due to access, infrastructure, and licensing restrictions from the publishers, it was not possible to text mine academic papers from Scopus. A workaround to this was to run a keyword search on Scopus database and export the results as comma separated values (csv) file with the titles and abstracts.

For the SBS 2035, the search was conducted in a different time compared to that of the project. Hence, the year of search was limited to 2020. The years that were searched for were 2018, 2019, and 2020. This was done to include and analyse only the most recent thoughts and opinions about the future of business school. Further, due to certain constraints of licencing the full text of the papers was not available and thus only title and abstracts were used. The search string for the search is displayed in table 24.

Using the 'pandas' library in pyhton3 programming language, only the abstracts was selected from the csv file. This was then written to a text file (.txt) ready for further text processing.

Table 24: data base search string SBS 2035 - ML

| Search string | Results |
|---------------|---------|
|---------------|---------|

| | |
|---|------|
| <p>TITLE-ABS- KEY (("future" OR "scenario*" OR "2035") AND ("universi t*" OR "higher education" OR "higher education institution*" OR "HEI" OR "H.E.I" OR "b-school" OR "b school" OR "MBA" OR "M.B.A" OR "Business School*" OR "Graduate school of business")) AND (LIMIT- TO (SUBJAREA , "BUSI")) AND (LIMIT- TO (PUBYEAR , 2020) OR LIMIT- TO (PUBYEAR , 2019) OR LIMIT- TO (PUBYEAR , 2018)) AND (LIMIT- TO (LANGUAGE , "English"))</p> | 3353 |
|---|------|

7.3.2.2. Twitter

Tweets from twitter was collected differently for SBS 2035 from that of EIBE. For the SBS 2035 project the twitter data was collected at the time when the project was running. This was done since the researcher had a non-commercial access to twitter API (Application Programming Interface). With this type of API twitter sets a limit on the timeline for searching tweets. The tweets were gathered using the 'tweepy' library in python3 programming language. Another limit that twitter had set was that no more than 100 tweets could be accessed in a single search and within certain time.

By the time of collecting data for EIBE, the researcher had access to the academic API version of twitter. Using this API, the researcher had access to archived tweets and the time frame for searching the tweets was flexible. For each of the search string (country name) the date range for searching the tweets was set between 01/01/2021 to 31/03/2022. This date range was chosen as this would cover the time period when most of the EIBE groups

worked on iteration two of their project. Since academic API was different from the standard API, the researcher had to adapt a custom code for downloading the tweets as opposed to using standard 'tweepy' library. All the coding was done using python 3 programming language.

The relevance of the search keyword strings was first tested on the twitter website and upon satisfactory initial results, the same string was then run on python3 to download the tweets. The following tables 25 and 26 shows the keyword strings used to download tweets for the respective cases.

Table 25: Twitter search string SBS 2035

| Twitter search strings for SBS 2035 | |
|--|------------------------------|
| | 'highereducation' |
| | 'university' |
| | 'future education scenario' |
| | 'future education scenarios' |
| | 'future businessschools' |
| | 'MBA' |
| | 'future classroom' |
| | 'future classrooms' |
| | 'highereducation scenario' |
| | 'highereducation scenarios' |
| | 'future lifelonglearning' |
| | 'scenarios lifelonglearning' |
| | 'future learning' |
| | 'future campus' |
| | 'future student' |

Table 26: Twitter search string EIBE

| Twitter search strings for EIBE MBA cases |
|---|
| 'chile' |
| 'argentina' |
| 'bolivia' |
| 'paraguay' |
| 'peru' |
| 'uruguay' |

7.3.2.3. Websites

For SBS 2035, website text information was retrieved by doing a google search based on the same keywords as that of twitter but with the right spacing and structure of words. Only the results from the first page were considered. Since many of the websites are dynamic, scraping them using programming code would have been very resource intensive, both in terms of computing as well as personnel resources. Thus, simpler option was to manually visit the URL from google search result, manually copy the text on the website, and store this text in a file (.txt) for further processing. This manual step was done in a manner to replicate the automated process.

For EIBE, the researcher was introduced to apify.com website by an industry expert. The researcher was able to use the trial version to scrape google search results up to the 100th page. All the URLs were then saved in .csv

format. Since the URLs were available as a list, it was possible to use python to automate the extraction of text from the website.

Python library called beautiful soup was used to download the text from the websites. The code was written to search for html '<p>' tags and to download that section. The '<p>' tags are html tags which indicates that the content within the tags contain only text. Unrelated text/noise was invariably downloaded. This was controlled during the machine learning modelling stage, where repeatedly occurring or very rarely occurring words were ignored.

7.3.2.4. Media Cloud explorer

"Media Cloud is a consortium research project across multiple institutions, including the University of Massachusetts at Amherst, Northeastern University, and the Berkman Klein Center for Internet & Society at Harvard University" (Media_Cloud, n.d). Based on search string(s), the media cloud website provides a list of URLs. The URLs are links to website where the search string has been mentioned in the content. How media cloud scrapes information is unknown, but the sources that media cloud scrapes are various news website from throughout the world.

Data from media cloud was only used to for SBS 2035 and not for EIBE. During the time of collecting data for EIBE, the media cloud website experienced some database issues, and the researcher was unable to download the URLs. Media could team have acknowledged this on their website and a screenshot of this is attached in the appendix.

7.3.3. Digital data sources pros and cons

It is well known and accepted fact that digital content and digitalisation is ever increasing. Blogs, Vlogs, Instagram, Youtube, Facebook, twitter, TikTok, etc., have an ever-increasing content and all of them are digital. Most of the academic journals are published online today. Increasingly, newspapers are moving to digital content only or maintain a print and digital content. Some news outlets have digital content only through their apps (e.g., BBC news; Sky News).

Academic papers which are generally considered to be as good quality source of data, have also been under scrutiny due to non-replicability (in prestigious journals such as Nature). And further, quality suffers due to publish or perish culture (Baker, 2016).

Other digital contents such as twitter, facebook, blogs, etc., have no quality control. For instance, using facebook to influence elections is being investigated by various countries (Sajid, Javed and Warraich, 2024). Blogs are known to have all sorts of opinions from well-balanced to outright fascists. However, there is an ongoing effort to improve the data quality being used for training AI models, for e.g., see: Rejeleene, Xu and Talburt (2024); Sambasivan *et al.* (2021); Salvatore, Biffignandi and Bianchi (2021).

Nonetheless, digital and social media are considered as sources for detecting weak signals, for e.g., see: Tumasjan, Braun and Stolz (2021); Pang (2010). As opinions are being expressed and published as digital contents which could contain weak signals. Hence the digital contents cannot be ignored. And thus, has been included in this thesis.

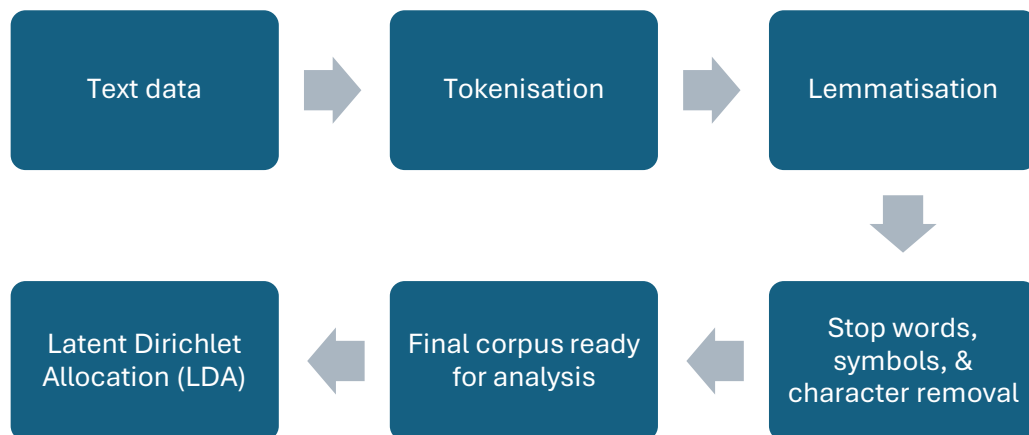
In the following section the text processing process will be explained.

7.3.4. Text processing

Data from each source was converted and stored in text file format (.txt). The text file was created separately for each source as the processing, or sometimes colloquially referred to as cleaning, was slightly different depending on the source. For e.g., data from twitter had a lot of #tagged (read as hash-tagged) words with grammatically incorrect and unstructured sentences. Whereas academic papers had a grammatically much neater and more structured sentences. But the general process is described in the figure 18 below.

The text processing was done using a combination of 'spacy' and 'nltk' libraries of python3 programming language. Tokenisation is the process of splitting up of the whole text document into individual token of words. For e.g., if the text data is "the dog jumped over the fence", after tokenisation it would be "the" "dog" "jumped" "over" "the" "fence".

Lemmatisation is the process of bringing back the word to its lemma or dictionary form. For instance, from the previous example the tokenised word



"jumped" would

Figure 18: LDA process

Source: Authors own rendition

be lemmatised to “jump”. Once this was done, words such as “the”, “or”, “is”, are removed from the corpus as they take up unnecessary computing resource while adding no value, and sometimes even hampering the analysis. Once the lemmatisation process was complete, the final text was the corpus and topics were modelled on the corpus by using the Latent Dirichlet Allocation (LDA) method. Having discussed the text processing in this section, the LDA algorithm will be presented in the next section.

7.3.5. Latent Dirichlet Allocation

Latent Dirichlet Allocation (LDA) (Blei, Ng and Jordan, 2003) is one of the most commonly used probabilistic models in Natural Language Processing (NLP) to discover hidden (latent) topics from a set of documents. It is based on the logic that a document is a distribution over topics and a topic is a distribution over words. Figure 19 schematically represents the logic behind LDA.

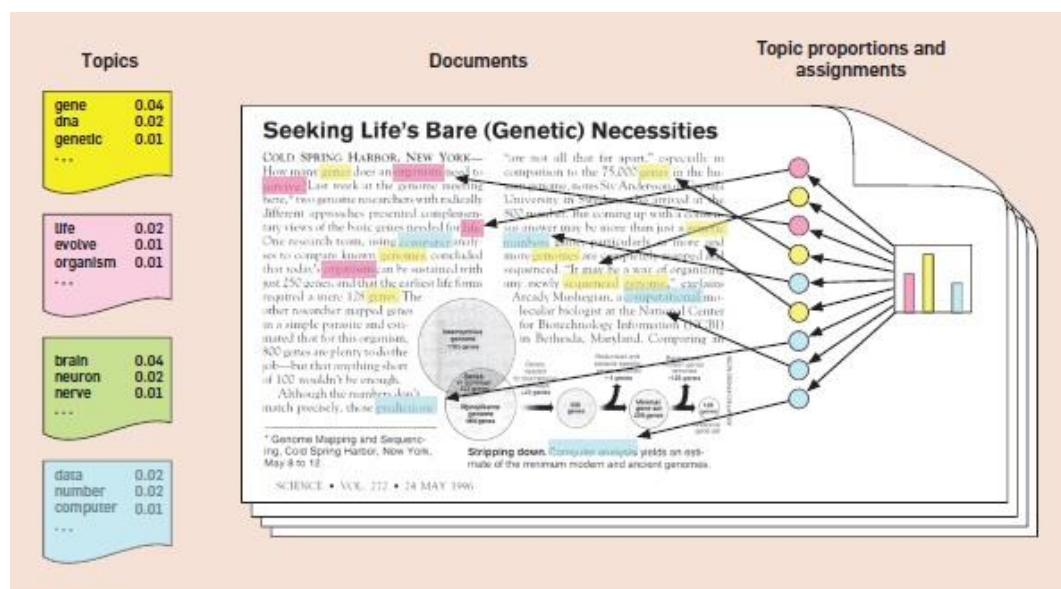


Figure 19: LDA
Source: (Blei, 2012. Pg 78)

To illustrate LDA (HSE), let there be a document named "document" which consists of the sentence "the cat meowed on the dog". For the ease of explanation, a typical topic and word association is presented in figure 20.

In the sentence mentioned earlier, there are two words occurring which are associated with topic 1 – Cat and meowed, which can be sampled with 40% and 30% probability respectively. Whereas just one word associated with topic 2 – Dog, which can be sampled with 30% probability. Thus, it can be inferred that the document is a distribution of two topics with 70% probability related to cat and 30% related to dog.

Please note that the numbers used in the above illustration are not mathematically derived and are imaginary (not to be confused with imaginary numbers in mathematics). The numbers are used to aid in simplifying the model for better understanding.

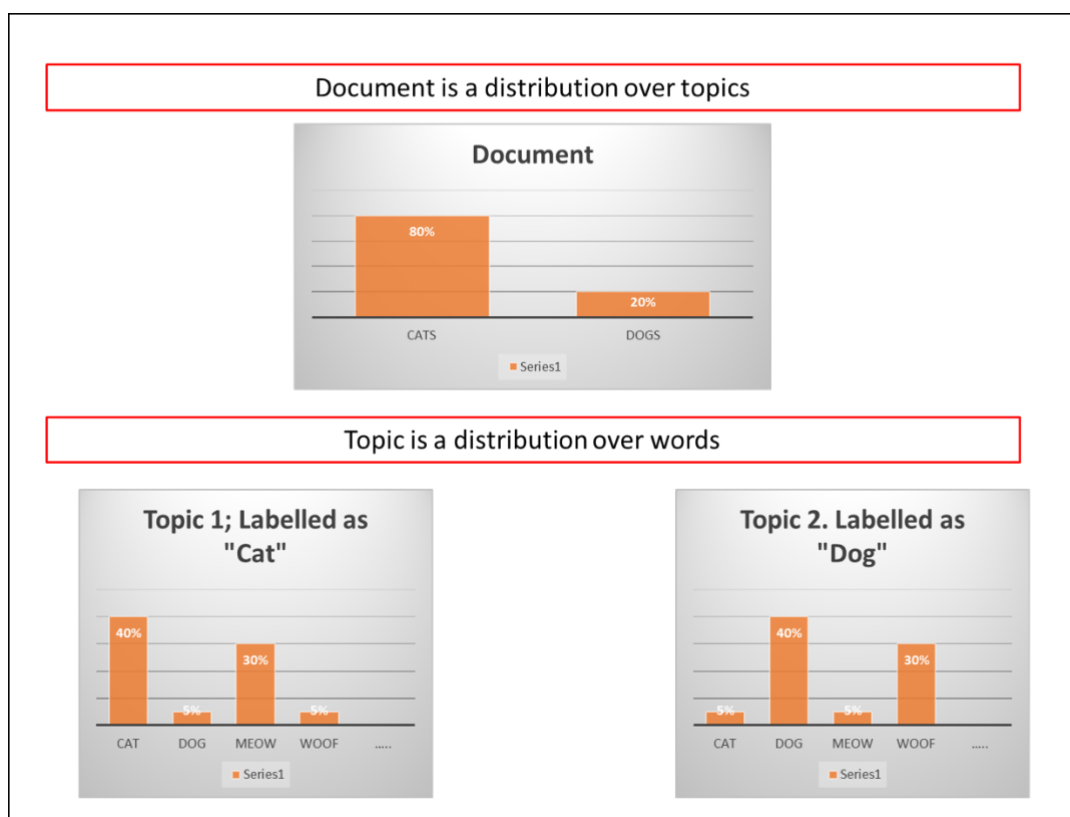


Figure 20: Topic, word distribution
Source: Author's own work

It should be noted that, contrary to the example above, the LDA model does not output labelled topics. Rather it outputs a list of words with probability weights for each topic. A representation of this can be seen in the left-hand side of figure 12. An example of a typically output (please note that it is not related to this thesis and is generated using a dummy data set) of the LDA model is as below:

TOPIC #0

['companies', 'money', 'year', 'federal', 'new', 'percent', 'government', 'company', 'million', 'care', 'people', 'health', 'said', 'says']

TOPIC #1

['military', 'house', 'security', 'russia', 'government', 'npr', 'reports', 'says', 'news', 'people', 'told', 'police', 'president', 'trump', 'said']

TOPIC #2

['way', 'world', 'family', 'home', 'day', 'time', 'water', 'city', 'new', 'years', 'food', 'just', 'people', 'like', 'says']

TOPIC #3

['time', 'new', 'don', 'years', 'medical', 'disease', 'patients', 'just', 'children', 'study', 'like', 'women', 'health', 'people', 'says']

TOPIC #4

['voters', 'vote', 'election', 'party', 'new', 'obama', 'court', 'republican', 'campaign', 'people', 'state', 'president', 'clinton', 'said', 'trump']

TOPIC #5

['years', 'going', 've', 'life', 'don', 'new', 'way', 'music', 'really', 'time', 'know', 'think', 'people', 'just', 'like']

TOPIC #6

['student', 'years', 'data', 'science', 'university', 'people', 'time', 'schools', 'just', 'education', 'new', 'like', 'students', 'school', 'says']

As can be seen from the above, the LDA model output is only a list of words, and the labelling needs to be done manually. For instance, Topic #0 could be labelled as 'government health care spending'.

The algorithm of the LDA model, as described by the inventors of the model (Blei, Ng and Jordan, 2003. Pg 996), is presented below:

The terms and notations are defined as follows:

- A word is an item in the vocabulary denoted by w and indexed by $\{1, 2, \dots, V\}$ where V is size of the vocabulary.
- A document is a sequence of N words denoted by $W = (w_1, w_2, \dots, w_N)$ where w_n is the n^{th} word in the sequence.
- A corpus is a collection of M documents denoted by $D = \{W_1, W_2, \dots, W_M\}$

LDA assumes the following generative process for each document w in a corpus D for a pre-defined number of topics k :

1. Choose $N \sim \text{Poisson}(\xi)$
2. Choose $\theta \sim \text{Dir}(\alpha)$
3. For each of the N words w_n :

- a. Choose a topic $z_n \sim \text{Multinomial}(\theta)$
- b. Choose a word w_n from $p(w_n|z_n, \beta)$ a multinomial probability conditioned on the topic z_n

Given the parameters α and β , the joint distribution of a topic mixture θ , a set of N topics z , and a set of N words w is given by:

$$p(\theta, z, w | \alpha, \beta) = p(\theta | \alpha) \prod_{n=1}^N p(z_n | \theta) p(w_n | z_n, \beta)$$

The diagram illustrates the components of the joint distribution equation $p(\theta, z, w | \alpha, \beta) = p(\theta | \alpha) \prod_{n=1}^N p(z_n | \theta) p(w_n | z_n, \beta)$. Red arrows point from each term to its corresponding process:

- An arrow from $p(\theta | \alpha)$ points to "For each document, generate topic probabilities".
- An arrow from $\prod_{n=1}^N$ points to "Select topic".
- An arrow from $p(z_n | \theta)$ points to "Select topic".
- An arrow from $p(w_n | z_n, \beta)$ points to "Select word from topic".
- An arrow from the entire product term $\prod_{n=1}^N p(z_n | \theta) p(w_n | z_n, \beta)$ points to "For each word".

Where α and β are the hyper-parameters of the model which represents the prior distributions.

One of the main challenges of LDA implementation is to choose the value – k , which is the number of topics. The most common method to find the optimal value of k is by making use of the topic coherence score. A grid search is conducted for various values of k with its respective coherence score and the k value with the highest coherence score is considered. But for the cases in this research, the highest coherence score did not always output a coherent model. The researcher had to fine tune by trying various k values before finalising the model.

The LDA model was deployed using the “Gensim” library in python programming language. The LDA model was run separately for each source

due to the nature of the language structure. For example, the language used in twitter was completely different from that of academic papers. Thus, a model trained on twitter might yield bad results when used on academic papers or vice versa. As mentioned earlier, the LDA model's output was a list of words with weight of each word for the topic. The labelling of the topic is done manually and is a subjective process.

7.4. Expert interviews

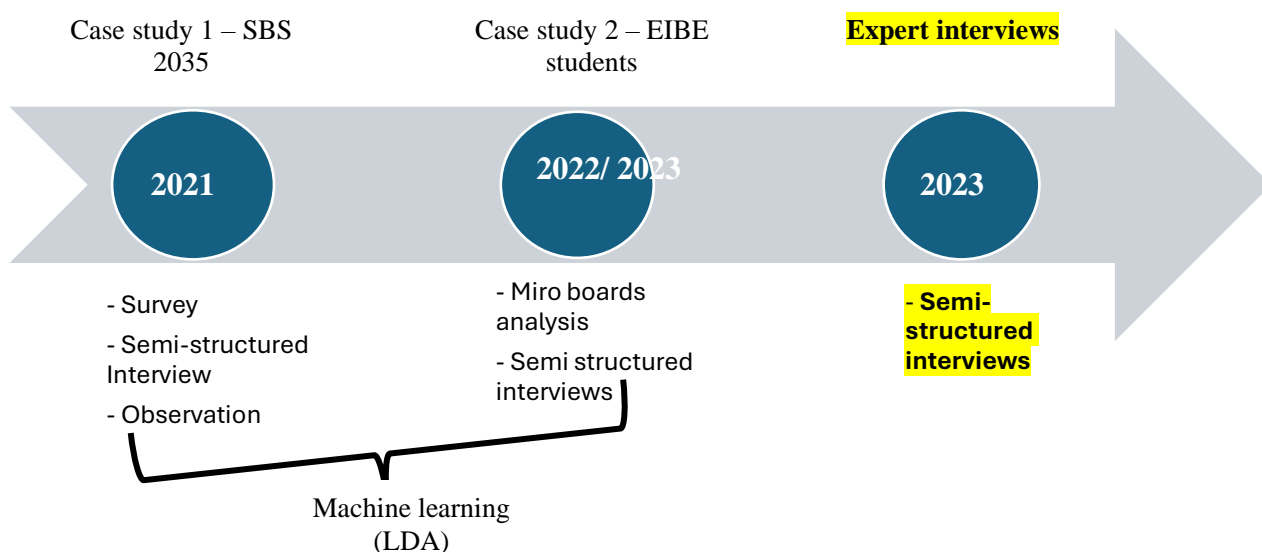


Figure 17: Case study and respective data collection methods

In the previous case studies the participants were chosen with the lens of investigating the opinions of novice participants of a scenario planning project. The term novice used in this context is to refer to those people who do not have or have very little experience in strategic foresight. Also, the

novices do not have expertise in AI (either programming or prompting). But this does not constitute that they lack any work experience. As many of the executive MBAs (participants) had some meaningful experience. Nonetheless, though the novices had some work experience, they did not have expertise in a particular domain or subject. Experts, within the context of this research, had strategic foresight expertise. Thus, novices in the context of this research refers to those people who are new to strategic foresight or those people who have been introduced to scenario planning recently.

In the present phase, the lens is changed to capture the opinions of leading experts in the field of strategic foresight.

Expert interviews are useful when there are few data available on the phenomenon in study, especially in complex decision making process (von Soest, 2023). As discussed in the literature review chapter, though there is literature on using AI for scanning weak signals, there are very few to none exploring the interaction of AI and filters of weak signals. Thus, interviewing experts would aid in “gaining information about or exploring a specific field of action” (Döringer, 2021, Pg 265).

Experts knowledge is based on either of the three processes – Experience, responsibility, and status (Van Audenhove and Donders, 2019). As presented later, the experts chosen for this case study were deemed experts as they satisfied one of the three processes. And in many instances, they satisfied more than one of the three processes.

The semi-structured interview allowed for an exploratory approach to uncover technical knowledge (Van Audenhove and Donders, 2019). Further as Van Audenhove and Donders (2019, Pg 185) state “It (semi-structured interviews) is used complementary to other methods to orient oneself in a new and/or complex field”. The interview was designed to probe the

“subjective knowledge and explanations given by experts” (Van Audenhove and Donders, 2019, Pg 185).

Before the advent of LLMs (Large Language Models), AI was limited to people with some specialist knowledge of coding and technology skills. But LLMs such as Bard, now Gemini (Google), and Chat GPT (OpenAI), it is possible for the general public to access AI without any specialist knowledge of coding or technology. This has given a raise in interest to explore the use of AI in many fields including strategic foresight. This was realised by the researcher when conversing with strategic foresight experts when attending the Scenario planning conference 2023 at Warwick Business School, Warwick University.

Though, originally, Chat GPT and other LLMs were not part of this research as these models didn't exist in the mainstream. For example, Chat GPT was released in November 2022. But these models had become the talk of the town and were straightforward to use. Which, as experts in the conference expressed, led to many of strategic foresight experts experimenting with it. And exploring how could LLMs impact driver and trends detection. Thus, the researcher decided to include expert opinions on the implications of LLMs within the scope of this thesis.

There is limited research on the use of LLMs within strategic foresight. A recent paper by Spaniol and Rowland (2023) explores how ChatGPT can generate scenarios itself. But the focus of this paper is on generating scenarios using LLMs and not on exploring the influence or effects of LLMs on detecting weak signals and the filters of weak signals. There are some literature that explore the use of weak signals detection through the use of AI such as deep learning and neural networks For e.g., see Ha, Yang and Hong (2023). But none study the impact or influence of filters of weak signal

whilst using AI. Also, most of these AI models using deep learning or neural network need specialist knowledge in AI engineering and computer coding.

Due to the lack of literature on weak signals and LLMs, experts can provide insights and therefore expert interviews suits well in this context. It should be noted that evaluating the performance of the LLM models or analysing it is not focus of this thesis. Further, LLMs are continuously evolving, and which inevitably means that there will be multiple versions of a particular model. There are paid and free versions of LLMs available with varying features and accessibility. For this research the free and open versions of Chat GPT and other LLMs were considered.

In chapter 6 the unit of analysis for this research was presented as “scenario planning activities” within the context of the scenario planning projects. By the virtue of a person being an expert in scenario planning would imply they would have experience in scenario planning project. Thus, the author sought to interview scenario planning experts. As mentioned in earlier chapters, the choice of sampling was convenience sampling.

The author had the opportunity to attend the ‘Scenario planning conference – 2023’ held at Warwick Business School, Warwick University. The conference organisers had invited a few highly reputed people as speakers in the conference. The author approached one of the speakers for interview, who kindly agreed to it. Post this first interview, the author used snowball sampling (Van Audenhove and Donders, 2019) to get references to other experts. This ensured that people who were interviewed qualified as experts. The author used his personal network and approached some well-established academics for providing references for possible interviewees. A total of 15 experts were interviewed.

The question of right sampling size is a common question that arises in qualitative research. But with no definitive answer (Guest, Bunce and Johnson, 2006;Dworkin, 2012). Though there are many suggestions ranging from minimum of 5 to many hundreds, it is impossible to put a quantified number as cut-off for acceptable number of interviews. The numbers vary depending on funding, time available, philosophical and methodological stances, and even based on stake holder expectations. Nonetheless, a sample size between 5 and 25 is acceptable (Creswell, 2013;Saunders, Thornhill and Lewis, 2015).

The following section contains the descriptive summary of the participants.

Descriptive summary statistics of the sample

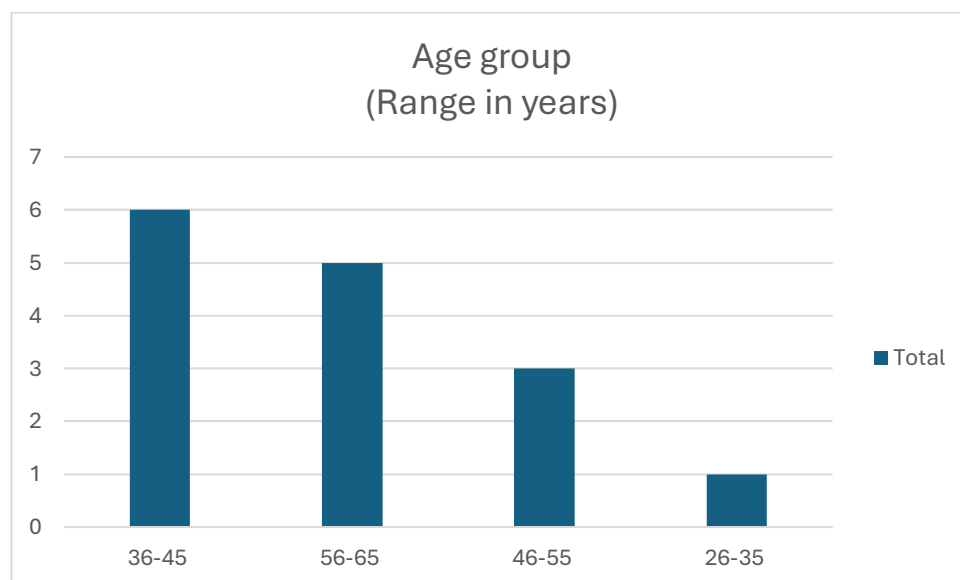


Figure 21: Participant age group

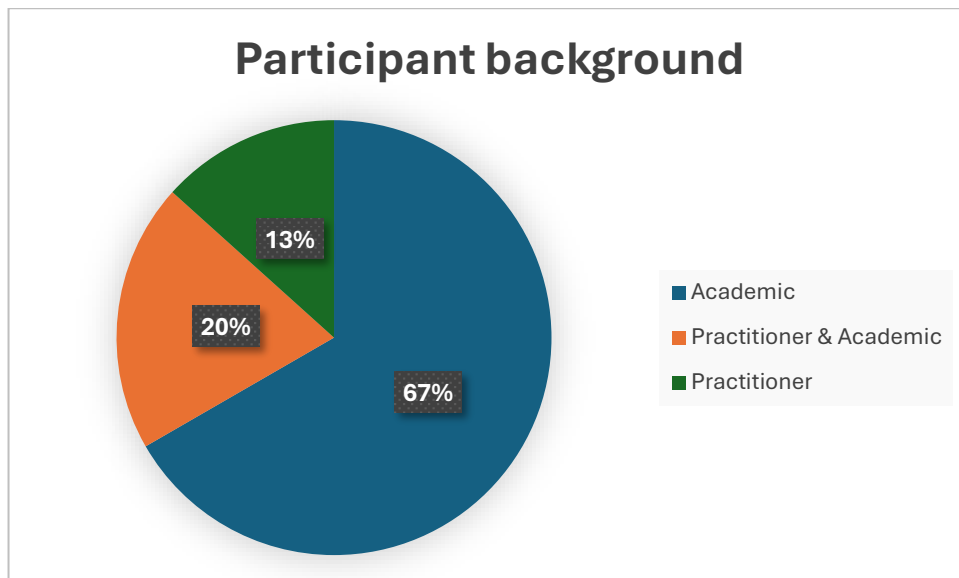


Figure 22: Participant professional background

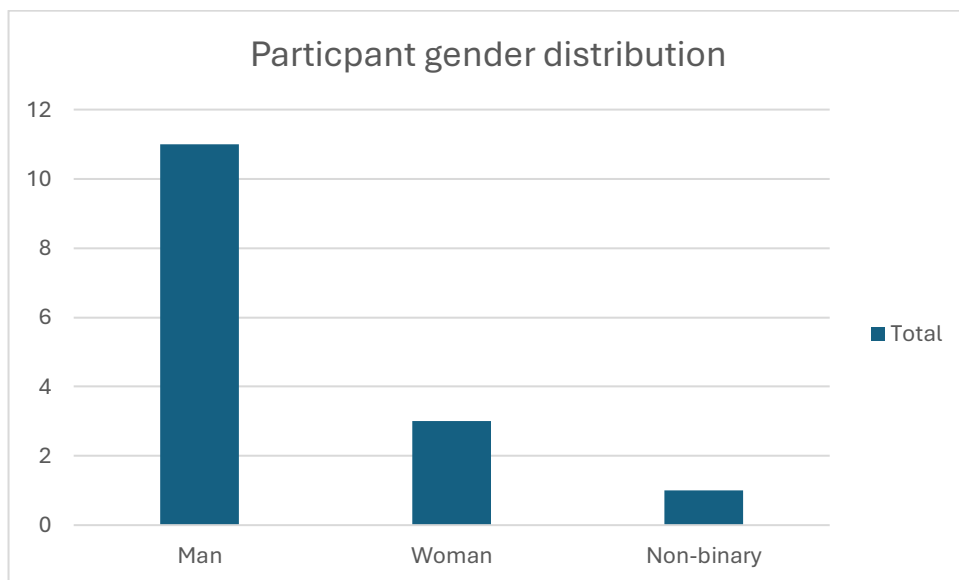


Figure 23: Participant gender distribution

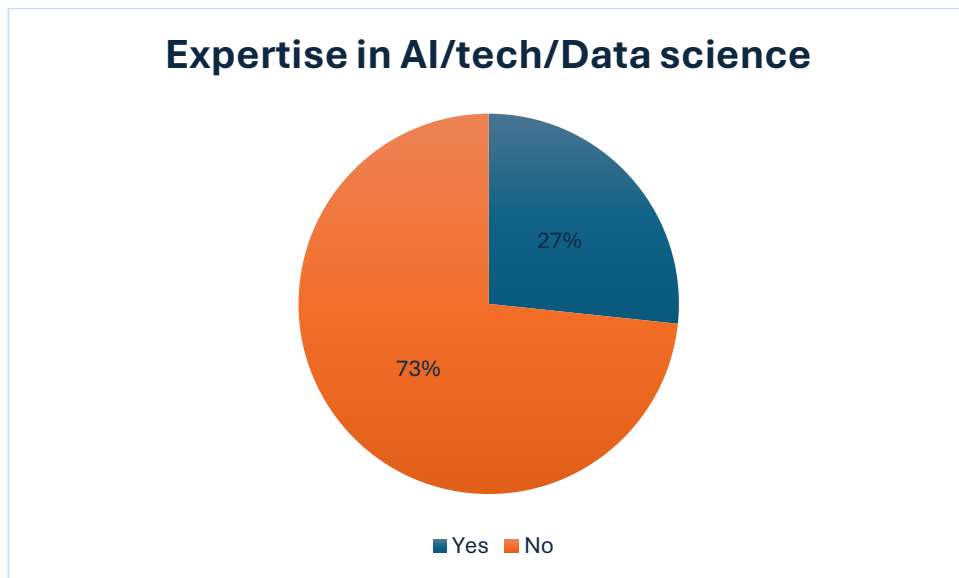


Figure 24: Expertise in AI/Data science

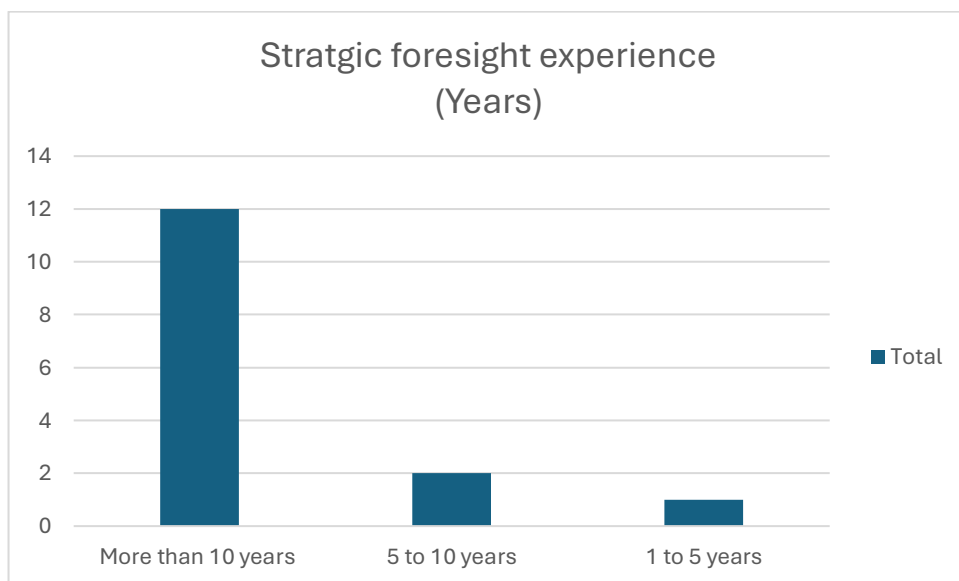


Figure 25: Participant experience in strategic foresight

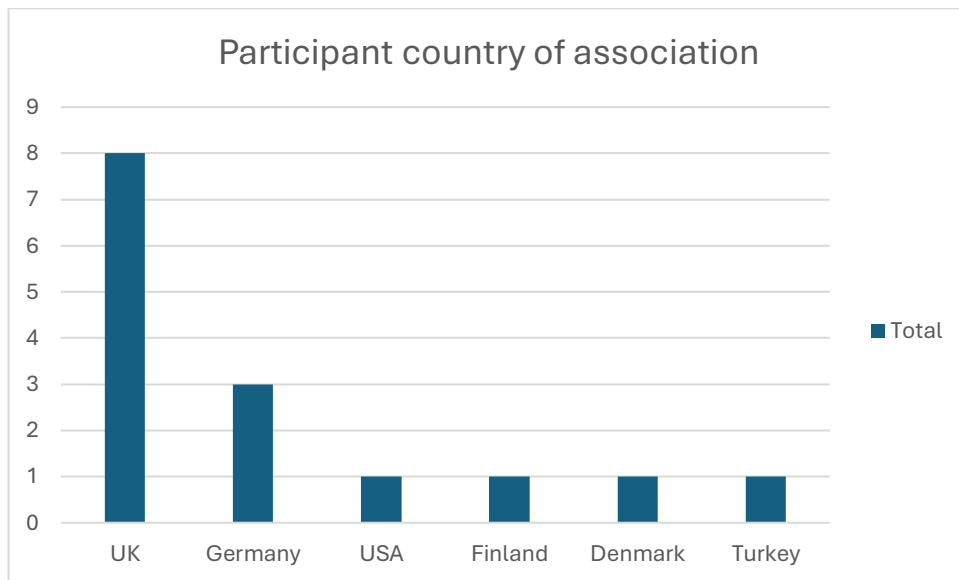


Figure 26: Participant country of association

Table 27: Expert interview Participant information

| Participant | Age group | Strategic foresight experience | Expertise in AI/ML/technology/data science | Expertise in using AI | Professional background | Gender | Country |
|-------------|-----------|--------------------------------|--|-----------------------|-------------------------|------------|---------|
| Person 1 | 56-65 | More than 10 years | N | Y | Academic | Woman | Germany |
| Person 2 | 36-45 | 5 to 10 years | Y | Y | Academic | Woman | UK |
| Person 3 | 36-45 | More than 10 years | N | Y | Academic | Man | UK |
| Person 4 | 46-55 | More than 10 years | Y | Y | Academic | Man | Germany |
| Person 5 | 26-35 | 1 to 5 years | N | Y | Academic | Non-binary | Turkey |
| Person 6 | 56-65 | More than 10 years | Y | Y | Academic | Man | Germany |
| Person 7 | 36-45 | More than 10 years | Y | Y | Practitioner & Academic | Man | UK |
| Person 8 | 36-45 | More than 10 years | N | Y | Academic | Man | USA |
| Person 9 | 36-45 | More than 10 years | N | Y | Practitioner & Academic | Man | Denmark |
| Person 10 | 36-45 | 5 to 10 years | N | Y | Academic | Woman | UK |
| Person 11 | 56-65 | More than 10 years | N | Y | Practitioner | Man | UK |
| Person 12 | 46-55 | More than 10 years | N | Y | Academic | Man | UK |
| Person 13 | 46-55 | More than 10 years | N | Y | Practitioner & Academic | Man | UK |

| | | | | | | | |
|-----------|-------|--------------------|---|---|--------------|-----|---------|
| Person 14 | 56-65 | More than 10 years | N | Y | Practitioner | Man | Finland |
| Person 15 | 56-65 | More than 10 years | N | Y | Academic | Man | UK |

From the above table 27, the majority of participants (80%) had more than 10 years of experience in strategic foresight. All the participants have used AI in scenario planning projects for scanning. And all the participants were aware of how to use LLMs including the complexities of prompting and were aware of the limitations of AI. Some of the participants (27%) were experts in AI and data science itself and were technologically aware of how AI and prompts work. Thus, sample of experts formed a robust pool of participants. In the next section details regarding the process of interviewing the experts will be presented.

7.4.1. Data collection method – semi-structured interviews

The prospective interviewees were approached by predominantly by email and in some instances by professional social media platform – LinkedIn. The email contained an invitation and a link to MS-Forms (hereon referred to as just Forms). Forms is a digital platform which is flexible in use. It can be used for range of activities from designing surveys to collecting opinions. Forms was secure as it could be accessed using only using the University log-in credentials.

The form designed by the author served the following purposes. First, it provided the basic context of the interview to the participants. This was based on the participant information form. The form also assured them of anonymity and confidentiality. Second, the form enabled the author to capture summary statistics of the participants backgrounds such as gender, age group, years of experience, and professional background. This is presented in the following section. Third, the form had a link to an online tool called 'calendly'. Calendly helped the participants to schedule a time for the interview based on mutually agreeable time. The MS-forms template is attached in appendices.

All the interviews were held virtually using the MS-Teams platform. The participants for the interview were not just scattered across the UK but were also from other countries. The author did not have resources to conduct in-person interviews considering the geographical travel involved. At the very beginning of the interview, the author sought the permission of the participant for recording the interview and, upon receiving the consent, the author initiated the recording.

The interview was designed as a semi-structure interview. As discussed in previous chapters, the author had developed an interview protocol that would help the author in steering the conversations. It should be noted that due to the nature of the semi-structured interviews, the interview protocol was a guide, and the author changed the order of questions, omitted, or probed depending on how the response from participants. But keeping in mind not to deviate from the overall objective contained in the protocol.

MS-Teams has the ability to generate transcripts automatically. Though it is quite accurate at most of the times, there are errors on occasions. Each transcript was checked and corrected by the author. The ethics approval mandated that the transcripts be confidential and accessed only by me or my supervisors. Based on the data management plan contained within the ethics approval, all the transcripts were securely stored on the OneDrive platform of the University.

Chapter conclusion

In this chapter, the three case studies were introduced. Since this is a multi-method research, the multiple data collection methods have been employed for each of the case studies. In the next chapter, the data analysed from each of the case with the respective method will be presented as separate chapters.

8. Data Analysis Case study 1

In the previous chapter, the case studies were introduced, and the data collection methods were discussed. In this chapter the analysis of the data of case study 1 will be presented. Answer to the research questions based on the analysis is provided. It should be noted that the answers are not the final findings but based on the analysis from this case study. The remaining case studies are presented as a respective chapter following this chapter. A final conclusion by comparing and contrasting the findings of individual case studies is presented later on.

Data analysis is that step which provides the meaning to the data from which insights can be generated to address the research questions. As mentioned in the earlier methodology chapter, this research is multi-method research. Thus, for each method of data collection the researcher has chosen a particular analysis technique.

For this case study, the data was collected using an exploratory survey and semi-structured interviews. The survey was analysed using descriptive statistics and the interviews using thematic analysis. Participant observation - the observations were noted, and the transcript was analysed for gaining insights.

Though there are umpteen number of analysis techniques, the choice of a technique is informed by a researcher's philosophical stance and personal preferences. In the following sections the descriptive statics for the survey and the thematic analysis for the interviews will be presented.

8.1. Data analysis – Survey

The intention behind this survey was not capture data for quantitative analysis such as regression analysis. Rather, the intention was to explore and

capture the trend of opinions of the people involved in the SBS 2035 project. Also, many of the participants in the SBS 2035 project were not available for an interview. Thus, to maximise the capture of opinions, this survey was taken up. For each of the questions in the survey, the response distribution is showed as a graph. All the questions were based on Likert scale and the extremes of the scale were: 1) strongly disagree; 2) strongly agree; and 3) the middle position was neutral. The questions were designed as statements as this was more appealing to the participants and would capture how they relate to the question.

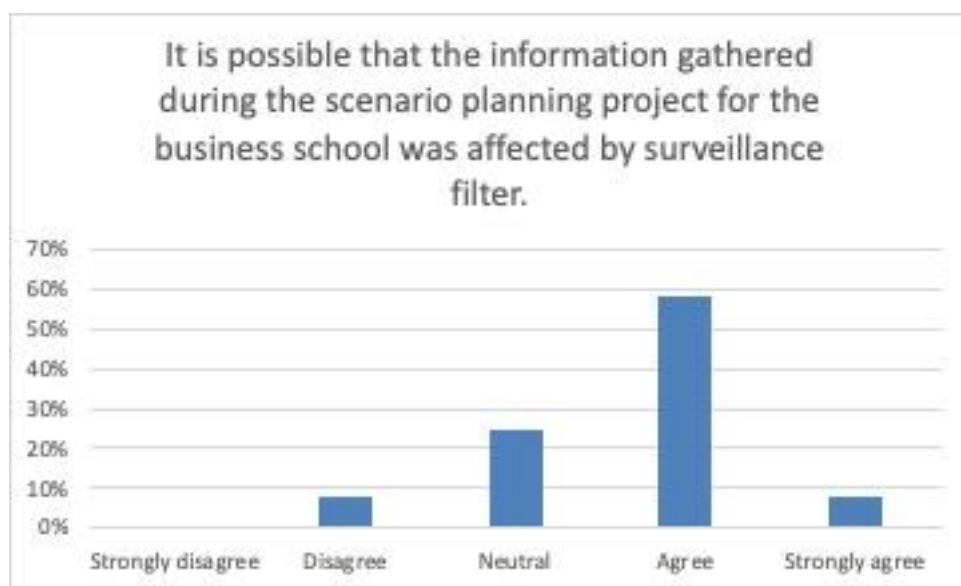


Figure 27: Survey question 1

The first question was "It is possible that the information gathered during the scenario planning project for the business school was affected by surveillance filter". The majority of the participants agreed to the statement as shown in figure 26. Even though the participants did not strongly agree, the response showed that the participants believed that the filters could have affected the data collection during the SBS 2035 project.

The next question was designed to check if quantitative methods would reduce the effect of filters. The question was "In turbulent environments, using extrapolation methods (example: forecasting) will filter out information on discontinuity". Majority of the participants agreed with the statement as shown in figure 27.

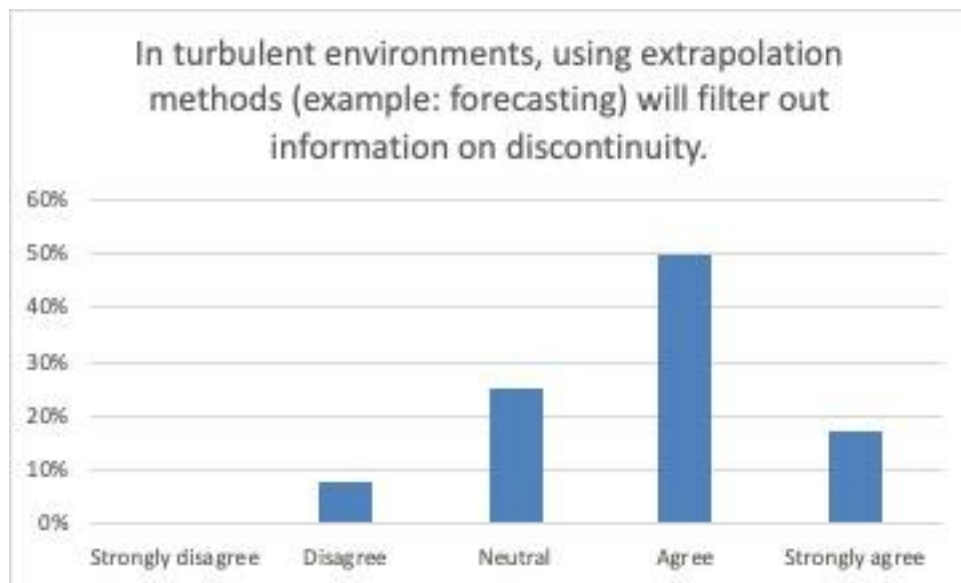


Figure 28: Survey question 2

The next question was "Machines are better than humans in recognising patterns from vast amounts of data and thus, can strike the right balance and overcome the surveillance filter". The reasoning behind this statement was to capture the participants opinion on the effects of machine learning on the filters. The majority of the participants were neutral as show in figure 28. This response was interesting as the word 'machines' was deliberately used vaguely. This was done as there were a lot of machine learning algorithms which could be used. Even with this, the participants were sceptical of machines in general.

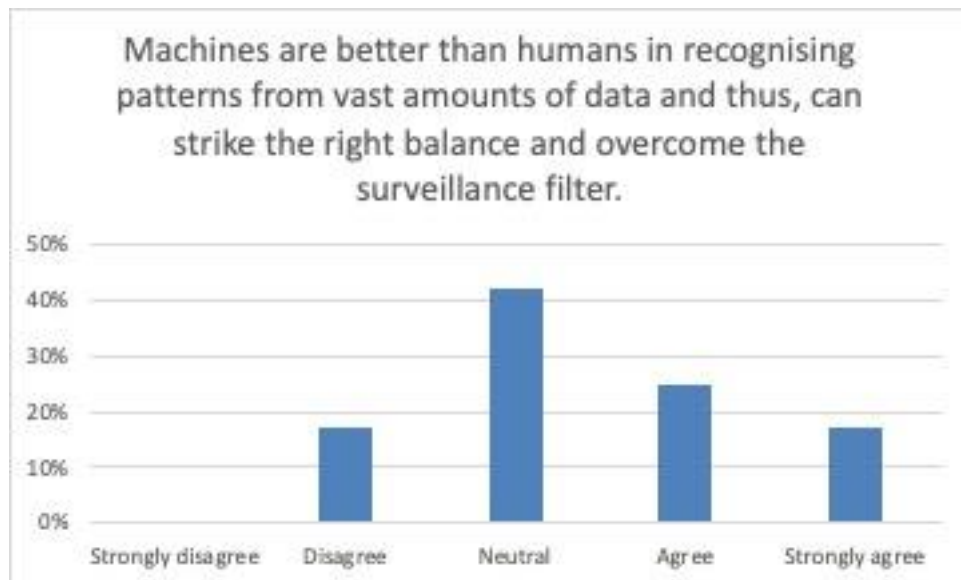


Figure 29: Survey question 3

The following question was "Managers, when observing the current market, pay attention to the features that have succeeded in disrupting their processes in the past". This question was designed to capture the opinion of the participants on mentality filter. Most of the participants agreed that mentality filter exists as shown in figure 29.

The next question was the same as the previous one but was worded differently so check if the response on the opinion on mentality filter was consistent. The question was "We observe our current market and pay attention to those features that have succeeded in disturbing our processes before". As shown in figure 30, the answers were consistent.

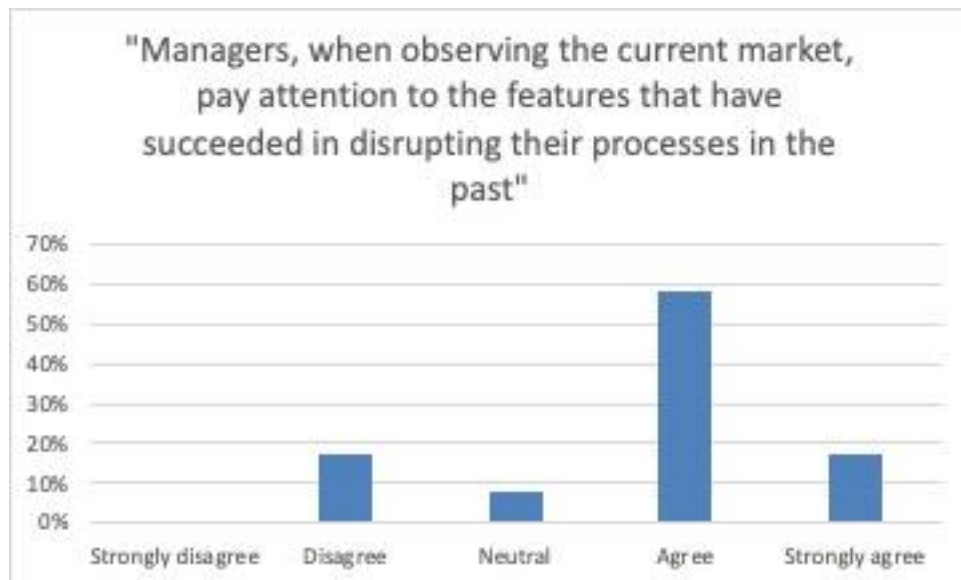


Figure 30: Survey question 4



Figure 31: Survey question 5

The next question was designed to capture opinion on the power filter. The question was "When people encounter an event, whose occurrence is so implausible, they hesitate to report it fearing they will not be believed".

The response to this question was mixed as participants were divided

between neutral, disagree and agree, strongly agree. This can be seen in figure 31. Thus, no conclusions could be drawn from the responses.

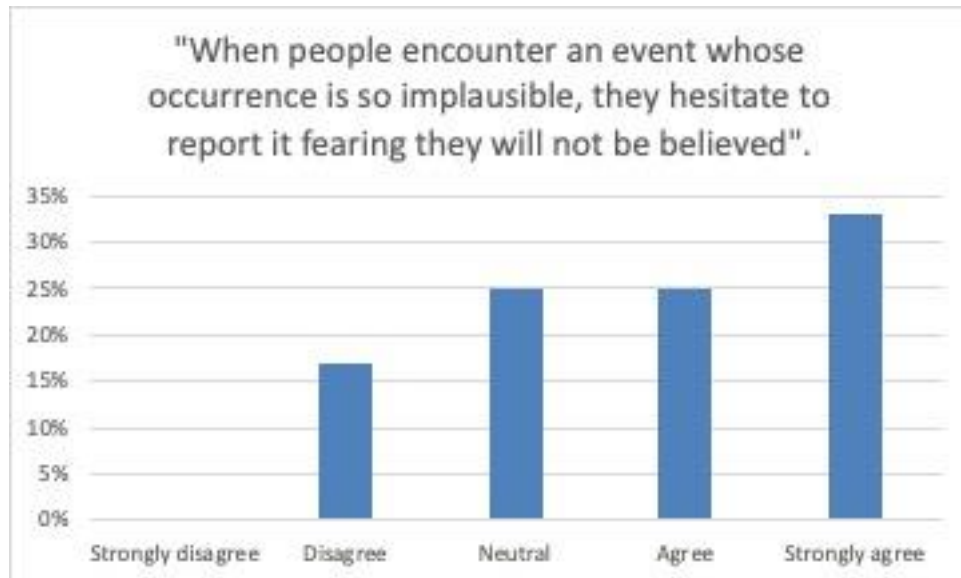


Figure 32: Survey question 6

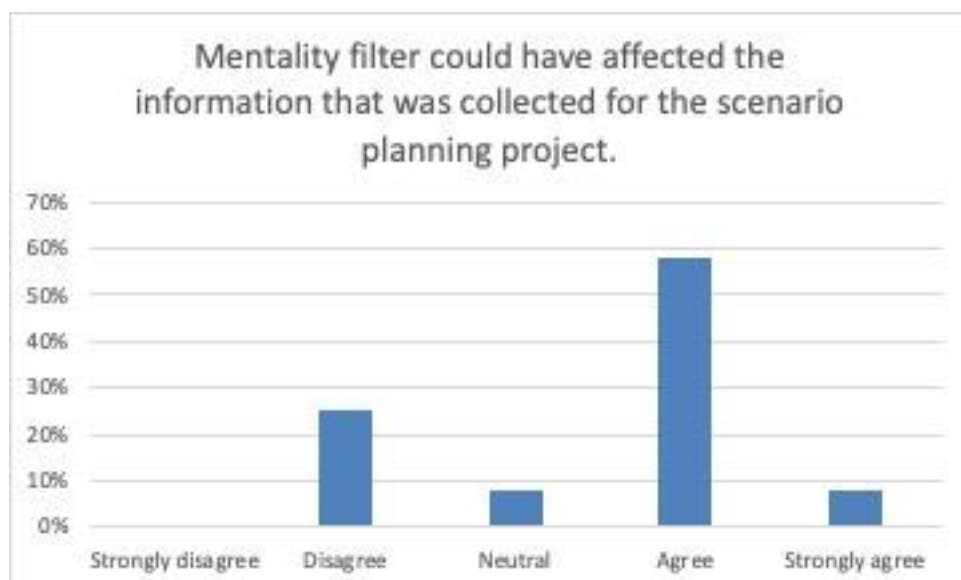


Figure 33: Survey question 7

The next question was project specific, and the question was “Mentality filter could have affected the information that was collected for the scenario planning project”. A few of the participants felt that mentality filter did not affect the project but majority of them did feel that the project was affected by mentality filter.

This question – “Machine learning can overcome mentality filter during horizon scanning”, was a straightforward question which was related to the crux of this thesis. The response this question was divided as with the previous question. Majority were neutral and some agreed (including strongly agree) as shown in figure 33. But none of them disagreed. This meant that there was a possibility that machines could overcome mentality filters, but this needed to be explored. A variation of this question is asked later to accommodate the uncertainty and the results are shown presented later.

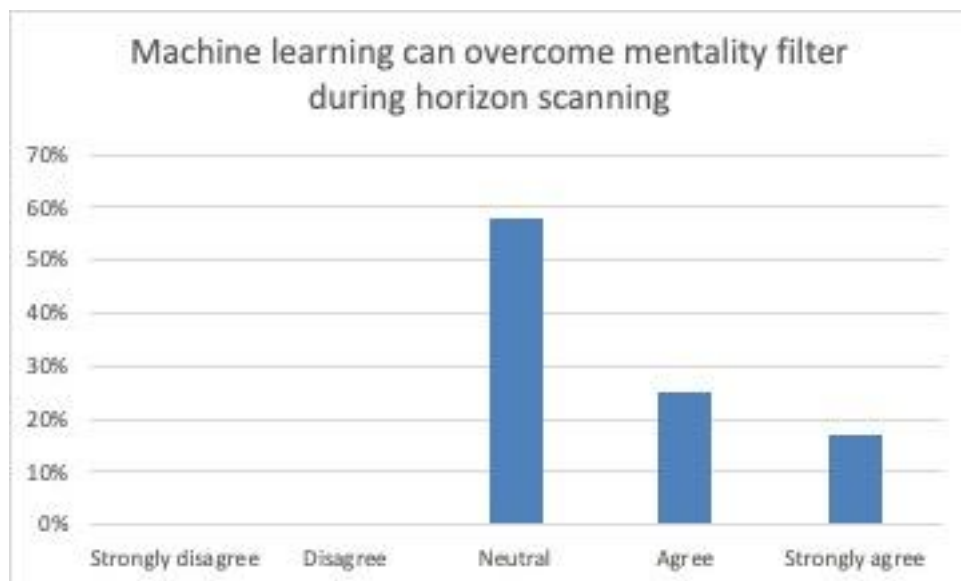


Figure 34: Survey question 8

The next question was designed to capture the experience of the participants on power filters. The question was “Have you encountered a situation within

this project where the information you provided was rejected or ignored as a results of power filters?" This was a yes, no, or not sure question rather than the Likert scale questions like the previous ones. The majority of the participants responded no. But it was interesting that a few mentioned not sure and a few more participants responded yes as shown in figure 34. Thus, it can be deduced that power filters are experienced by a few and thus this filter exists.

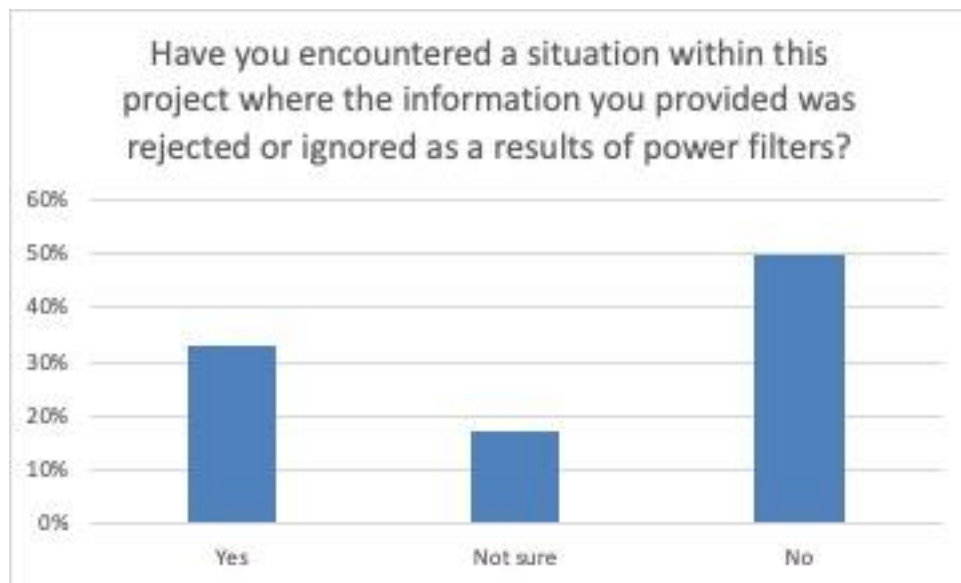


Figure 35: Survey question 9

The final question was "It is plausible that machine learning can overcome mentality and surveillance filters". As mentioned earlier, this was a different version of the previous question "Machine learning can overcome mentality filter during horizon scanning". The reason for this question was to accommodate the perception of the participant with the uncertainty of the machine's performance. This is why the word plausibility was used. For this question the overwhelming majority felt that machine's, plausibly, can overcome mentality and surveillance filters as shown in figure 35.

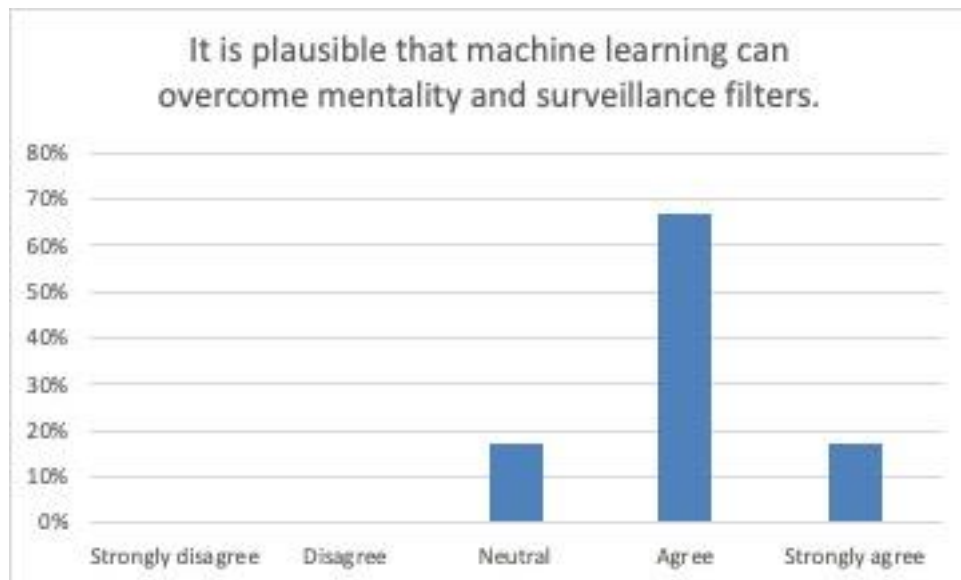


Figure 36: Survey question 10

To summarise the above survey responses, majority of the participants agreed that filters actively affect weak signals. But chose to be neutral with regards to machines overcoming the filters of weak signals.

In the following section, the semi-structured interview analysis framework and the analysis will be presented.

8.2. Data analysis method: semi-structured interviews – Thematic Analysis (TA)

Generating the transcript is said to be the first step for a researcher to familiarise themselves with the data. But the analysis really begins when the data is analysed using an analysis method of choice. Based on the data collection method, the tool of analysis can vary depending on the philosophical standpoint. For this research a qualitative analysis method was chosen.

The most common methods of analysing transcripts are thematic analysis (TA) (Braun and Clarke, 2006), interpretative phenomenological analysis (IPA) (Smith, 2009), Grounded theory (GT) (Glaser and Strauss, 1999), and discourse analysis (DA) (Coyle, 2007).

As Braun and Clarke (2013, Pg. 184) mention "GT is an approach to qualitative research not just an analysis method". Thus, even though GT is a popular choice for qualitative research, it was not in line with the approach of this research. Another popular qualitative analysis is DA. But, similar to GT, "DA is not a method; it is not even an approach to qualitative research. Rather, it is a whole approach" (Braun and Clarke, 2013, Pg. 187). Thus, DA was not considered for this research as the approach and beliefs of the researcher were not compatible. Another popular analysis method is the IPA. But the method is more suited for exploring people's lived experiences or experiential learning. This is not related to the aims of this thesis and hence was not used.

TA, unlike the methods mentioned previously, is just a data analysis method. It does not prescribe to a particular approach, data collection methods, theoretical position, and philosophical position. Thus, it is quite a flexible tool to analyse and answer most types of qualitative research questions. TA can be applied to experiential or critical data (Braun, 2022). Considering these advantages, the researcher decided to employ TA for analysing the data.

Table 28: TA advantages & disadvantages

| Thematic Analysis | |
|--------------------------|----------------------|
| Advantages | Disadvantages |
| | |

| | |
|--|--|
| Highly flexible through theoretical freedom | Lack of literature on TA as compared to, for example, Grounded theory |
| Easy to grasp | Lack of literature will lead to novice researchers question the rigour of their research |
| Useful in summarising key features of large datasets | Flexibility can lead to lack of coherence and inconsistency |

Source: (Nowell et al., 2017)

There are six phases in TA. First is to familiarise with the data, followed by coding. The next step is to explore and search for themes. Once the themes are explored, the next step is reviewing the themes. The final step is generating the report (Braun and Clarke, 2012; Clarke and Braun, 2013). The steps are schematically represented in figure 36 below . The first step, familiarising with the data was done during transcription. The second step, coding, is explained in the following section.

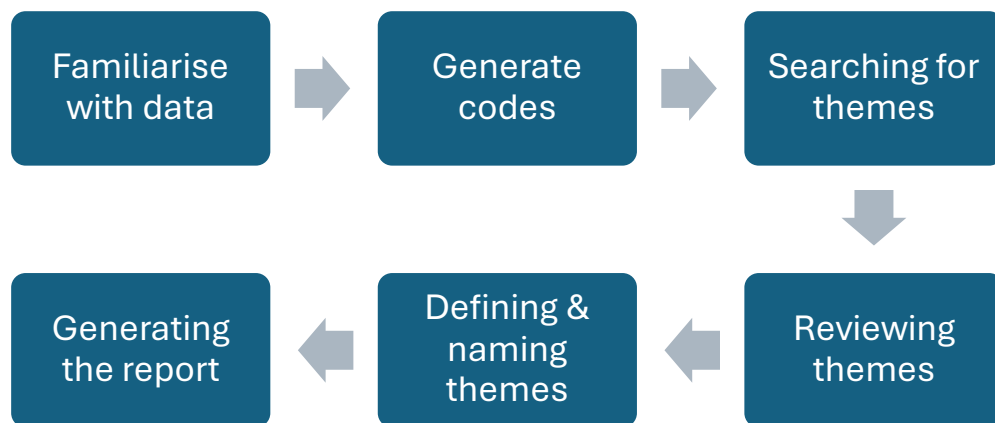


Figure 37: TA steps
Source: Author's own work

8.2.1. Coding

To do TA on the data, the transcripts need to be coded. Coding is “the process of exploring the diversity and patterning of meaning from the dataset, developing codes, and applying code labels to specific segments of each data item” (Braun, 2022, Pg. 53).

The main approaches to coding are selective coding and complete coding. In complete coding anything and everything is coded to find interesting patterns. This is a common choice of grounded theory researchers (Braun, 2022). Selective coding on the other hand involves identifying those parts of the data that is interesting to the researcher. Driven by the philosophical and personal preference of the researcher, selective coding was opted as the preferred method of coding.

A code is usually a short word or phrase that “symbolically assigns a summative salient, essence-capturing, and/or evocative attribute for a

portion of language based or visual data” (Saldaña, 2013, Pg. 3). Codes are usually of two types, data driven or semantic codes, and researcher derived or latent codes. Data derived codes are usually a short summary of the data written or annotated by the researcher. Latent codes are based on the theoretical or conceptual interpretation of the data by the researcher (Braun, 2022). But in practice, whilst coding the data, it is difficult to distinguish between the two. As Braun (2022, Pg. 207) state “ [the] separation between semantic and latent codes is not pure”. This is also reflected in the codes that were generated by the researcher for this research.

For the coding process, the data was transferred from text file format to Nvivo software. Nvivo is a software developed with a focus on analysing qualitative data. The software has a lot of options and features. It also has the capability to support a wide range of qualitative data analysis methods.

8.2.2. Searching for themes & reviewing the themes

A theme in TA is, as Braun (2022, Pg. 77) states, “... a pattern of shared meaning organised around a central concept”. And each theme has its own “central organising concept” Braun (2022, Pg. 77). Generating initial themes is a creative process and this process is influenced by (Braun, 2022):

- The researcher’s skills and the knowledge of the material
- Personal knowledge of the researcher
- There is no single correct endpoint
- The quality can vary significantly

Generating themes is an iterative process which involves exploring, developing, reviewing, and refining themes. For this thesis, the researcher exported the codes from Nvivo to excel. These codes were then exported

further on to a Miro board for initial exploration and “playing around” with data as to get a feel for it.

But to ensure the quality of the themes, Braun and Clarke (2012, Pg. 10) suggest that researchers should reflect on the following whilst developing the themes:

- Is this a theme (it could be just a code)? And if it is,
- What is the quality of this theme (does it tell me something useful about the dataset, and my research question)?
- What are the boundaries of this theme (what does it include and exclude)?
- Are there enough (meaningful) data to support this theme (is the theme ‘thin’ or ‘thick’)?
- Are the data too diverse and wide-ranging (does the theme lack coherence)?

Once the initial exploration was completed, the researcher went back on to the Nvivo platform to export a matrix of data. The matrix was exported to an excel file. The matrix contained, as the first column, all the codes. The subsequent columns contained each of the transcript file name and the number of times the respective code (based on the row) was mentioned in the transcript file. This matrix helped the researcher to visualise and compare the pattern of coding across various interviews. The codes were clustered to form a theme.

8.2.3. Identifying themes, and naming & defining themes

The first step to identifying a theme, was to identify a pattern in the codes. The pattern was identified by clustering the codes that were similar. As an analogy, the clustering looked like a tree (please refer to figure 37). The

codes are leaves, which are connected by arrows acting as branches. All the branches pointed towards one bark which was the theme.

Miro was used for the first clustering process as it is a very intuitive platform. All the codes were first imported on to the Miro board as virtual post-it notes. Once on the board the post it notes could be freely moved around. This was similar to what would have been done on an actual white board. The codes were clustered and again re-clustered iteratively. Once the researcher was satisfied with the clusters, a name was given to the cluster which formed the theme for that cluster.

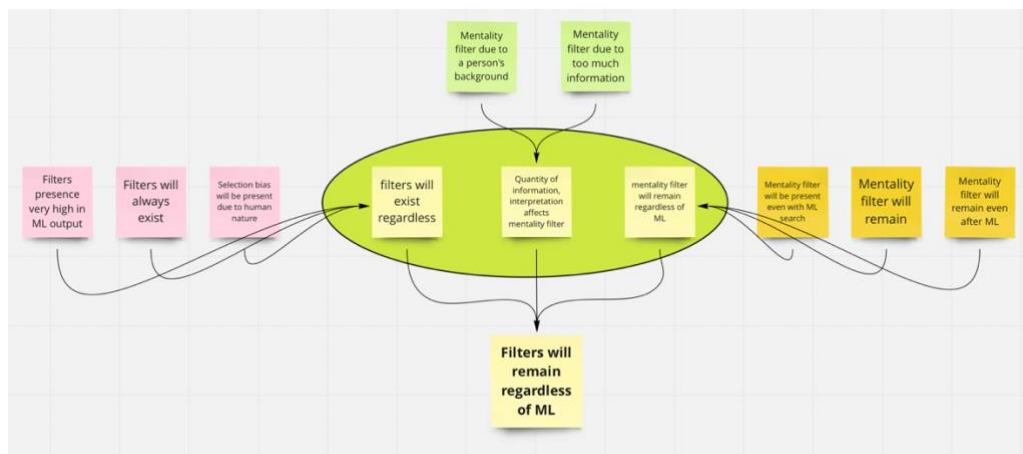


Figure 38: Theme example 1

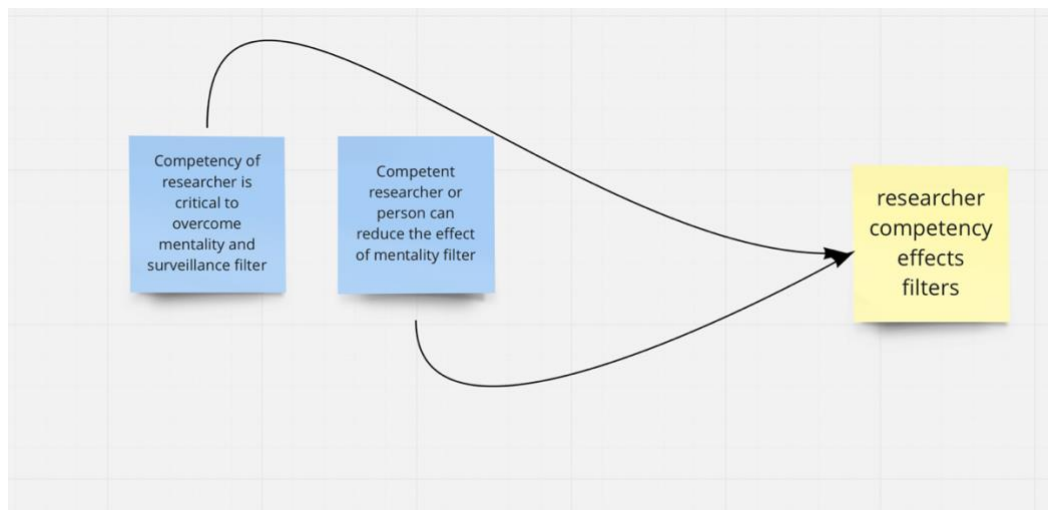


Figure 39: Clustering example 1

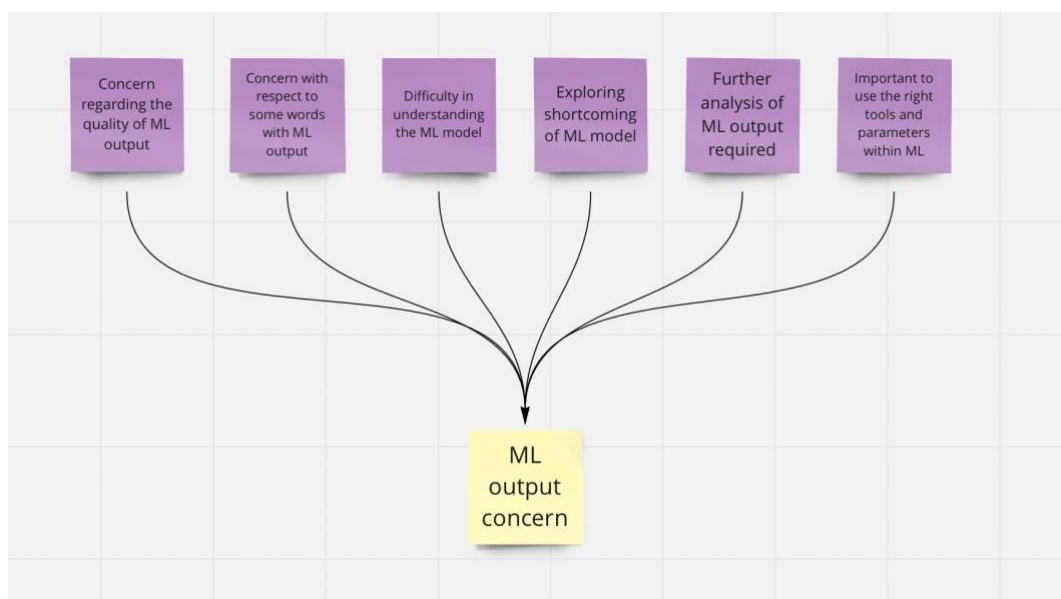


Figure 40: Clustering example 2

Themes were identified based on the clustering process on Miro as mentioned before. And a name was given to the theme. This was then transferred back to Nvivo. The theme names were added as the parent nodes on nvivo. Under each parent node (theme), respective codes were moved as child nodes. This enabled Nvivo to map the codes to occurrences

and its respective file (transcript). Figure 40 is an example of this. The blue highlighted node is the parent node “Non – ML data is challenging to work with and analyse”. Below this parent node, shown in the figure with an indent, are the child nodes.

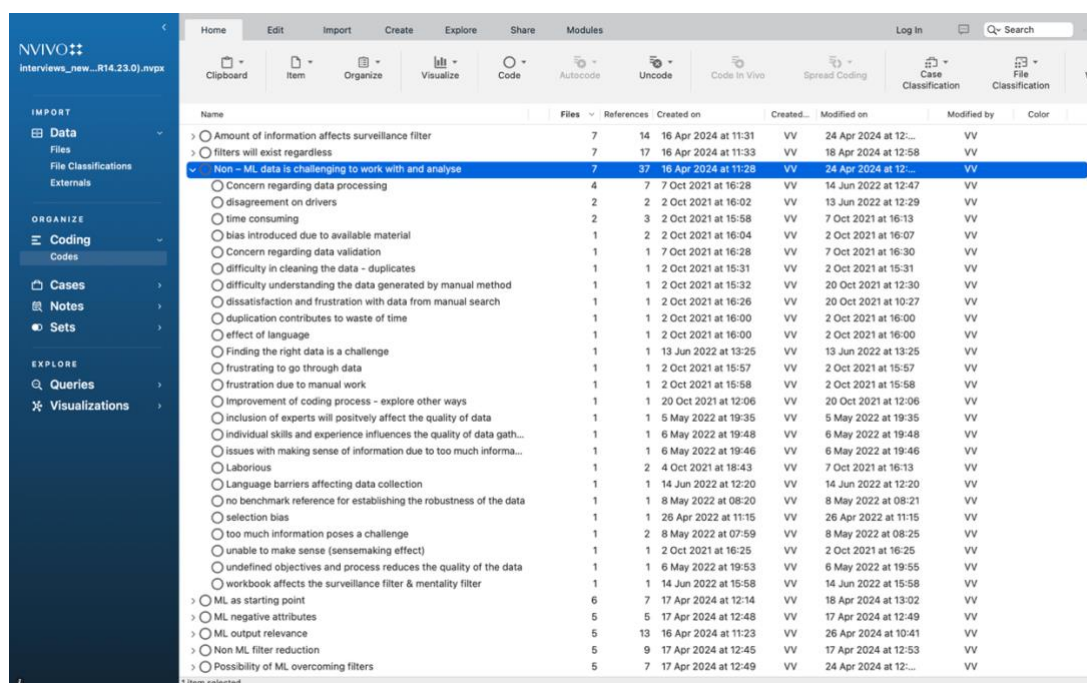


Figure 41: Nvivo theme and node example

A total of 17 themes were identified. The following table 29 shows the themes identified. Nvivo allowed the automatic mapping of themes and occurrences. For instance, in figure 40, the blue highlighted parent node (theme) – “Data related issues – Non ML” – was connected to 7 interviews. This number of connections to interviews will be referred to as ‘occurrences’ hereon.

Table 29: Theme and occurrence matrix

| | A | B | C | D | E | F | G | H | Occurrenc e | % |
|---|---|---|---|---|----|---|---|---|----------------|---------|
| Non-ML data is challenging to work and analyse | 4 | 3 | 2 | 6 | 11 | 8 | 1 | 0 | 7 | 88 % |

| | | | | | | | | | | |
|--------------------------------------|---|---|---|---|---|---|---|---|---|------|
| filters will exist regardless | 3 | 1 | 0 | 3 | 4 | 2 | 2 | 1 | 7 | 88 % |
| Surveillance filter effects | 4 | 4 | 1 | 1 | 2 | 1 | 0 | 1 | 7 | 88 % |
| ML output relevance | 3 | 3 | 0 | 2 | 4 | 1 | 0 | 0 | 5 | 63 % |
| ML overcoming filters | 2 | 1 | 1 | 0 | 1 | 0 | 0 | 2 | 5 | 63 % |
| Non ML filter reduction | 0 | 1 | 1 | 1 | 1 | 5 | 0 | 0 | 5 | 63 % |
| Mentality filter cause or effects | 0 | 2 | 0 | 1 | 1 | 1 | 0 | 0 | 4 | 50 % |
| Non ML process or project issues | 0 | 1 | 0 | 2 | 2 | 2 | 0 | 0 | 4 | 50 % |
| Acceptability of ML | 0 | 0 | 0 | 2 | 4 | 1 | 0 | 0 | 3 | 38 % |
| Bias through humans | 4 | 0 | 0 | 4 | 0 | 2 | 0 | 0 | 3 | 38 % |
| ML as starting point | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 3 | 38 % |
| ML issues | 2 | 0 | 0 | 3 | 4 | 0 | 0 | 0 | 3 | 38 % |
| ML negative attributes | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 3 | 38 % |
| mentality filter reduction | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 2 | 25 % |
| ML data concerns | 0 | 0 | 3 | 0 | 0 | 0 | 1 | 0 | 2 | 25 % |
| methods of reducing filters after ML | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 13 % |
| Researcher competency | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 13 % |

Though 17 themes were identified not all were related to the research objectives of this thesis. In TA it is important for the themes to meaningfully communicate towards answering the research questions (Braun and Clarke, 2013). Further the thickness or the thinness is determined by the interpretations of the researcher, based on their experience rather than using

a quantitative cut-off. As there are no known benchmarks or standards for applying cut-offs in qualitative research (Braun, 2022). Rather, as with qualitative research, the emphasis is on the meaning as opposed to the quantitative research emphasis of confidence, correlation, etc. Thus, it would be counterintuitive to apply such quantitative cut-offs for determining the relevance and thickness of the themes.

The following themes were considered to be relevant from the 17 themes identified as presented in the below table 30.

Table 30: Relevant themes case 1

| Theme | Occurrence | Occurrence in % | RQ |
|---|-------------------|----------------------------|-----------|
| Non – ML data is challenging to work with and analyse | 7 | 88% | RQ 1 |
| ML output relevance | 5 | 63% | RQ 1 |
| Filters will exist regardless | 7 | 88% | RQ 2 |
| Amount of information affects surveillance filters | 7 | 88% | RQ 2 |
| Possibility of ML overcoming filters | 5 | 63% | RQ 2 |

8.2.4. Interpreting the theme

The researcher was aware of the manual data collection process by scenario planning participant through his own experience as a participant in SBS 2035 project as well as by sitting in (as an observer only) the MBA class called EIBE class (used as multiple cases in the next phase of the empirical study). The researcher was also able to get insights on the data gathering practices

through various informal interactions with academics and colleagues during the course of his PhD.

The overall impression was that manual data collection, as with any method, had its own advantages as well as disadvantages. But considering the vast amount of digital data generated every day the manual data collection would only become a liability. The researcher was also informed by various literature, which was discussed in detail in the literature review chapter, that manual data collection practices are affected by biases and that data mining techniques can overcome or at the very least reduce these biases (For e.g., see: Mühlroth and Grottke, 2018).

But the researcher had an impression that the manual data collection or driver detection versus the data mining techniques needed much deeper scrutiny. On the surface, the machine seemed to be the logical choice compared to that of human. But, as discussed in the literature review chapter, this line of thinking required further scrutiny.

In the previous section, the data coding process and clustering were presented. In this section, how these themes communicate meaning to answer the research questions will be presented. To interpret the themes the research question presented in the earlier chapter 3 is recalled here:

RQ1: How can Artificial Intelligence or Machine Learning enhance weak signal detection?

RQ2: How can Artificial Intelligence or Machine Learning alter the process of perceiving weak signals in the context of filters of weak signals?

The following table 31 maps the themes with that of the research questions.

Table 31: Themes and RQs mapping

| Theme | RQ1 or RQ2 |
|---|-------------------|
| Non – ML data is challenging to work with and analyse | RQ 1 |
| ML output relevance | RQ 1 |
| Filters will exist regardless of ML | RQ 2 |
| Amount of information affects surveillance filters | RQ 2 |
| Possibility of ML overcoming filters | RQ 2 |

Analysing themes related to research questions – Case 1

8.3. Themes analysis related to Research Question 1

The first research question is:

RQ1: How can Artificial Intelligence or Machine Learning enhance weak signal detection?

The following themes address the above question:

- Non – ML data is challenging to work with and analyse.
- ML output relevance.

The analysis of each of the above themes are presented below.

Non–ML data is challenging to work with and analyse

The cluster for this theme varied from questioning the validity of data classification (coding) by participants, to frustrations due to duplication and the amount of manual work involved.

During the SBS 2035 project, and in other scenario planning projects, the data was coded usually using the STIRDEEPER or PESTLE frameworks. The data coding was done by participants in an individual capacity. And the team would implicitly trust the coding and the reliability of the data done by each of the team member. But this implicit trust on the reliability of the classification or coding of the data under the various headings and subheading was questioned.

This line of scepticism on the validity of the coding of the drivers can be seen from an excerpt of the interview.

"And the second concern I think that's raised is that there was no process for validating the contributions of individuals. That was almost taking me, as a coder, at face value and assuming that I had some domain expertise and was able to do that and I caught everything properly so there's a big question about reliability, as well as bias" (P1A21, Interviews 2021).

Another issue with manual data collection for driver detection was duplication. Some of the interviewees used a strong word, frustration, for expressing their emotions. This data sorting, invariably, added more time to the project and thus contributed to more labour. The below two excerpts from two different interviews shows the effect and emotion of data cleaning on project participants.

"Because of duplication, it just made things worse because we have to look at it again and again through the same thing and some of it" (P1B21, Interviews 2021).

"It was very frustrating, because each and every cluster that was there had the similar... similar... sort of feel to it, and when looking at those like 20, 25 odd clusters there, in everything had the same drivers, it was it was very frustrated" (P1B21, Interviews 2021).

The sheer number of information available today due to digitalised content is overwhelming. This, combined with participants working remotely, would attribute to difficulty in making sense of the data gathered. Also, when the number of people scanning for drivers increases, duplication and vast quantity of data are bound to be created. One of the interviewees expressed the same opinion and below is the excerpt.

"... you know if there's say 12 people or 20 people [and] are all scanning the internet and looking at various reports looking at organizations... you know...

looking at data... it was too much... you know that and how do you make sense of all that" (P1C21, Interviews 2021).

As mentioned earlier, when the number of scanners increase so does the vastness of the data. This would lead to a lot of labour for sorting through the data, cleaning it, and identifying the drivers of change. This labour-intensive work has the possibility of affecting the productivity of the project participants. As one of the interviewees stated:

"The... codification of all of our content and the workbook development is... is... an extremely Labour-intensive exercise. That is... that's for sure, and with probably are some questions, not just about productivity, but effect of this" (P1A21, Interviews 2021).

The vastness of available data also means that locating the relevant data becomes a challenge. As an interviewee states:

"... we did find it very, very challenging. To... to... get all of the information required. Especially if it's a topic that's that seems... as if they're at odds with one another... because you're talking about... you know... brand new hugely uncertain picture of the pandemic with a very established entity like XXXXX, XXXXX... so I mean trying to marry those two things together was actually very challenging" (P1D21, Interviews 2021).

Overall, the vast amount of accessible data available to scanners is overwhelming and at the same time difficult to locate the relative data within the vastness. This leads to duplication which in turn leads to frustration. All of this implying that there will be a drop in productivity. The duplication added with vast amount of data has led the scanning activity to be a very labour-intensive exercise. Another question that has been brought to light is on the validity and reliability of the drivers that have been scanned by the

scanners. Which, in most cases, had been taken for granted to be of acceptable quality.

ML output relevance

The machine learning output (LDA model) was shown to participants, and their opinion was sought during the interviews. As mentioned in the previous section, the majority of the survey participants expressed that they believed that machines could be helpful but remained neutral on its ability to detect weak signals and reducing the effects of weak signal. On similar vein, when the interview participants were presented with the output of the machine learning model, they were wondering on how relevance it would be. The first concern was with respect to the cluster of words for a topic. The participants were concerned that if the machine learning (ML) output (cluster of words) was, by in itself, a good representation of the driver. Another concern was that the ML output was too basic and was difficult base the drivers on just some cluster of words. The following interview excerpt shows this concern.

"But I just don't know if those words... that itself are enough to be confident about that stage like if... if... the outcome of that stage was those list of words... I'm not quite sure... I don't know... I don't know if it's not went far enough for me to just trust that completely for that stage" (P1E21, Interviews 2021).

The ML method used for this section was LDA where the ML outputs clusters of related words. The name of the cluster is assigned subjectively by the users of the output. And due to this, the reliability of the labelling was questioned and in turn the usability of ML output.

"I suppose... The question I've got is how. I wouldn't come up with those manually assign labels just from those words. There I would need to see

other information and prompts and what did the person who came up with the label see... not just those words..." (P1A21, Interviews 2021).

"... because I think I would probably be more negative about the machine learning, but if you'd only present those words, because I believe we don't quite get exactly... you are kind of guessing what exactly is it" (P1E21, Interviews 2021).

Another concern with respect to ML output was on its feasibility and practicality. Especially, since many of the participants in a scenario planning project might not have a background in ML or AI methods. The following excerpt from an interview where the interviewee questions the applicability and use of AI.

"And how practical it is again I don't know..." (P1F21, Interviews 2021).

As discussed earlier, data is ever increasing in size and number, and this is creating challenges for effectively analysing them by human. Purely due to sheer size. The challenges of manual data search and analysis was discussed in the theme "Non – ML data is challenging to work with and analyse". This would intuitively lead to the line of thought that machine should be able to do a better job in collating and analysing data.

But, as discussed in the second theme – ML output relevance, the relevance of the LDA machine learning model output was raised by the interview participants. As the output was a cluster of words which needed further interpretation. Further the labelling of the clusters is a subjective process. The subjective process contains the risk that the person labelling the clusters could be influenced by the filters such as preconceived association or experience. Which could be projected on to the label itself. This raises the

possibility that important signals could be distorted or ignored due to the subjective labelling.

It should be noted that the ML model that was used in this case study was LDA which has been discussed in depth in the earlier chapter 7. The model was run between 2020 – 2021. There have been many developments in AI have post this. Notably, Chat GPT (Open AI) and Gemini (Google). The usability of these models has been explored in expert interviews which will be discussed in later chapters. Thus, the above analysis should be put into context of 2020 – 2021.

Though there were concerns on ML, majority of the participants felt that there could be a use for ML and that it should be further explored. The participants were probed on the ability of ML to overcome the filters. Overwhelmingly, participants were of the belief that the filters will always remain regardless of ML. This will be discussed in the next section.

8.4. Themes analysis related to Research Question 2

The second research question is recalled here for the benefit to the reader:

RQ2: How can Artificial Intelligence or Machine Learning alter the process of perceiving weak signals in the context of filters of weak signals?

The following themes address the above research question:

- Amount of information affects surveillance filters
- Possibility of ML overcoming filters
- Filters will exist regardless of ML

Amount of information affects the surveillance filters

The amount of data available and the scanner's background such as education, profession, etc., have an influence on the surveillance filter. There is a huge amount of data available today due to the ever-increasing digitalisation of everything. But the quality of data mined within the context of this thesis is unknown. With some of the data containing unreliable and opinionated information. This presents a problem to the scanner. As the scanner had to sift through a lot of irrelevant information in order to obtain usable information. The following interview excerpts express this concern.

"And you could also obviously create a massive amount of data... Much more than that a person could probably deal with and but does it result in a lot of irrelevant information that you then have to sift through" (P1D21, Interviews 2021).

"so exactly so [we] had huge amounts of data of work book" (P1G21, Interviews 2021).

Sifting through huge amount of information is not only laborious but will also mean that a lot of interpretation takes place whilst sifting. This interpretation of information by will be susceptible to filters of weak signals. As one of the interviewees states:

"Because the topic is so broad, we were looking at 2030 as a base case. And Covid had just hit... it wasn't like... this is not a precedent... there is no precedent for having something like this right. [omitted as inaudible] and we were trying to formulate a future for Glasgow. Which is a big city with loads and loads and loads of possibilities, so I mean, the scope is too vast and what happened was we did get lost" (P1B21, Interviews 2021).

Overall, as humans it is easy to lose focus when there is a lot of information and data available contributing to the surveillance filters. The scanner's background will also influence what the scanner will focus when going through the data. This in-turn will influence the surveillance filter.

Possibility of ML overcoming filters

From the SBS 2035 project, majority of the participants expressed that machine learning (ML) could possibly overcome the filters of weak signals. This was more of an opinion expressed by the interviewees rather than expressing about something that they had experienced.

The opinions hovered around the capability of the machines to scan huge amount of data compared to humans. This was based on the participants' assumption that the ability of machines to analyse huge amount of data implied that machines are more exhaustive than humans. The following excerpts from one of the interviews is a representation of the opinions expressed.

"When machine does this part of the job that is not in a way soft but it's hard and it's doing the scanning, I think that's that could be very beneficial to the project or to the to the process..." (P1G21, Interviews 2021).

"[Machines] can enable the process to run smoother and more... I would say it this way, you can capture more... more niches or more... more nuances that be... could [be] overlook [you]... [you] know maybe [when] it's done by a person" (P1G21, Interviews 2021).

"Capability of machines that... ummm... potentially... that there is a way where a computer... like the computer searching [inaudible] that computer could almost... It [is] probably more subtly and quicker than us... um... so

obviously goes through [a lot of] data, so you probably could have some confidence that it is more exhaustive because there's obviously, no, well..., I know you don't have to input, but there's less human interaction which assume reduces kind of biases" (P1E21 Interviews, 2021).

Though these were valid opinions, it was based on the personal view of the interviewees. And they were not necessarily experts in machine learning. Also, even though interviewees were positive about the possibility of machines doing an exhaustive search, they did mention concerns attached to this. This was presented in the theme "ML output relevance". This in a way was counterintuitive to the opinions mentioned in the present theme.

Filters will always remain regardless of machine learning

With the obvious advantage of machines with regards to its ability to search vast amount of data at high speeds, its use to overcome the filters of weak signals was probed. The participants were of the opinion that ML could possibly overcome surveillance filter to a certain extent, but mostly the filters would still exist. The overwhelming majority of the interviewee stated that, one way or the other, these filters would exist even with machine learning. As one of the participant's states:

"... and I really like this idea of the mentality filter because you know we are humans, you know we are... we are humans" (P1C21, Interviews 2021).

Implying that filters will remain simply because it is in the very nature of humans to be biased.

The clustering of the words as patterns from a corpus is done by the machine without human interference. But labelling a particular topic (cluster of words) is done by humans. This labelling exercise projects the filters

rather than overcoming the filters by the machine. The following excerpt from two separate interviews discuss this point.

"Very high because all the person has got is their perspective on the overall scenario. And what they believe about it and then they have 10 words to prompt them. And then, they have to make some sort of leap of faith and come up with... come up with a label for each topic so I would say that the level of bias and prejudice and... and... the surveillance that would be many surveillance filters being applied to this exercise" (P1A21, Interviews 2021).

"... um so obviously goes through the data, so you probably could have some confidence that it is more exhaustive because there's obviously no well, I know you don't have to input, but there's less human interaction which assume reduces kind of biases and stuff I do wonder there's that as an output of the machine learning there's still that human issue with you labelling it manually" (P1E21, Interviews 2021).

Further, even with the use of ML, participants will have their biases and may select, or discard information based on their liking and or beliefs. As one of the participants states with respect to this:

"you know we're human and, of course, you could be exposed to intelligences or literature here... which you don't particularly like... you know... you may not like some of the... you know... the future scenarios and even the trend data on population, you may not like on climate change, you know... you may know what you know... so you might disregard" (P1C21, Interviews 2021).

Thus, regardless of using ML for detecting drivers and weak signals, the filters seem to still exist.

As discussed in the literature review chapter, Ansoff (1975) proposed that weak signals are affected by three filters during the process of scanning, detecting, and perceiving weak signals in the 70s when there was no digital data. Today, due to digitalisation the amount of information that is available is vast. Thus, invariably, these processes are affected by it. Further, as presented in the previous section, there is an absence of control on the quality of data. But machines have the ability to scan vast amount of data with relative ease as compared to humans. Which leads to the belief that there is a possibility that machines can overcome the filters of weak signals. But the machines lag behind in analysis as, presently, they are incapable of cognition.

Further, filters will exist regardless of ML. As the data upon which the machines have been trained have been generated by humans. Collectively the human generated data will contain various biases, stereotypes, various beliefs (For e.g., religious or political), propaganda, etc. Machines invariably learn from these and have been known to suffer from it (For instance, on AI and racism see: Zalnieriute and Cutts (2022)). This problematic data will affect the output from machine learning. And as humans interpret this output, the filters as proposed by Ansoff will exist.

In this section the analysis from eight semi-structured interviews were presented. In the following section the data analysis from the researcher's observations of a group will be presented.

8.5. Data analysis process – participant observation

The context and the necessary background on the group observation was presented in the earlier chapter 7. In this section, the observations by the

researcher during the group labelling exercise and the responses by the group members will be presented.

At the very beginning the researcher briefed the group on SBS 2035 and the aims of the session. The aim was to label the topics from the ML output. The label would be considered as drivers of change for SBS 2035. The participants were also very briefly briefed on the scenario planning to give them an understanding as to why they were doing what they were doing. Finally, the participants were given a quick brief on the machine learning method and how the machine came up with the list of topics as output. The whole session lasted for about four hours including small breaks and a lunch break.

One of the first observation that the researcher made was that it took almost 20 minutes to explain the machine learning (ML) output to the participants. This was even after an introduction letter was sent to the participants before the event. The letter contained information on the machine learning output. The participants did indeed read the letter as this was confirmed by the researcher.

The second observation was that of herd mentality. Initially the participants began discussing on how to go about the labelling and they were organising themselves such as who would moderate etc. When the labelling began, even though there were some discussions, the participants very easily agreed with each other. When there was a vocal voice, the participants tended to follow, creating a herd mentality. There was a tendency from the participants to agree when most of the others were in agreement, albeit reluctantly for the sake of moving forward. This behaviour is similar to power filter which was discussed in chapter 2/3.

After some time into the labelling exercise, there was an interesting development. The participants, unknown to themselves, formed subgroups. A few of them were following one vocal individual and other few followed another vocal individual. The individuals within the subgroups took sides by supporting and agreeing with the respective vocal person of the subgroup.

Another interesting observation was that, as time progressed, the subgroups disappeared, and the participants became more vocal individually. At the same time, the exhaustion of all the participants was quite visible. Even with breaks, the participants displayed signs of tiredness.

At this time, the participants were inclined to finish and therefore ready to compromise their voice and opinion. As one of the participants stated:

"it's a mentality filter for [example] like the fact that we were under pressure to... or shall we say I fell under pressure to get through this quickly. Especially taking longer and longer. So, we were more inclined to think a little bit less comprehensively as we got further down the list" (P1JO21, Observation participant 2021).

Clearly, this affected the work they were doing and in turn it affected their ability to perceive weak signals. As the group wanted to complete the task in haste and finish rather than contemplate weak signals.

Once the labelling exercise was finished, the researcher presented the Ansoff's framework on how weak signals pass through three filters before the signals become information. The researcher also explained the three filters – Surveillance, Mentality, and Power, to the participants. After this, the researcher probed the participants for their reflections on how the filters could affect labelling drivers for topics generated by machine in general and

if they felt these filters would have affected the labelling exercise that they did.

The participants, upon reflection, felt that there was a good possibility of filters affecting the drivers search. The participants also felt that the filters would affect the driver's detection regardless of whether machine learning was used. The following excerpt from the discussion shows how mentality filter affected the labelling.

"... last point about having a child in the words, I quickly... my bias was that I have a child, and I have that recent experience about what she's sharing and what they are teaching her in school. So, I completely missed on that point, and I was thinking more about childcare" (P11O21, Observation participant 2021).

This shows that the word 'child' in the machine learning output could be interpreted differently by different people depending on their personal experiences and circumstances. Thus, altering the perceiving of weak signals.

The participants were also of the belief that surveillance filters and mentality will always exist as humans are biased based on their past experience and wishful thinking. This can be seen in the following excerpt of a participant discussion:

"During the pandemic anything that was mentioned... you know... different platforms that are available different learning environments... campus... that kind of idea... face to face... that's absolutely gonna have influenced how you saw things. Because certain words are going to jump out at you, you know... like human and stuff... human can have jumped out at me, and I think that was because I missed that interaction experience. So that will

definitely make me more likely to ignore other aspects that other people may pick up on" (P1JO21, Observation participant 2021).

The participants also felt that information may be filtered by people when their own survival may be at stake if a certain driver is identified thus contributing to the mentality filter. And thereby affecting the quality of weak signals detected. An excerpt from the group session mentions this:

"And yes, mentality filter, of course, if especially if there was some information that really wouldn't be something good for me in the future, I might be like oh that won't happen. Right like something to make making me, you know redundant in the future, well, that would be something I would maybe you know avoid to think about and take into consideration" (P1KO21, Observation participant 2021).

Even though participants felt that power filter did not apply in this case, it was contrary to the observation of the researcher. Even though the participants were vocal about their own line of thought, it was observed that there was a herd mentality many times. That is most of them would align and agree to the most vocal or seemingly confident person for a particular topic.

Also, the participants were also of the opinion that power filters are affected by the group power dynamics. An example would be the dynamics of the group changing due to the presence of a person in a position of power. As one of the participants put it:

"Probably the power filter... the power bias is not applicable in this case, at least to me because we are third parties, discussing these things if we have had been in organizations which deal with stuff then it could have been the point. Or if we would have been one of the stakeholders within this scenario

planning exercise, then the power filter would have come into play, much more, but that is not the case here” (P1LO21, Observation participant 2021).

Another insight from the discussions was that mentality filter affected the labelling of topics generated by the machine. As there was a possibility of picking words from the topic that the scanner was interested rather than holistic approach to the cluster of words. As of one the participants states:

"When we are reading into the whole text there might be bias, as you said, the very purpose of the exercise, there might be biased in picking up certain parts of it or interpreting it in a particular way. On the other hand, there might be words, which are much more important that we... than what importance we gave during our exercise because might tend to overlook some words but that might be the crux of the very..." (P1LO21, Observation participant 2021).

Based on the above observations and probing the participants, the influence of fatigue, herd mentality, and influence of personal background alters the process of perceiving (filters) weak signals.

Chapter Conclusion

In this chapter the data analysis of case 1 was presented. Starting with the survey, moving on to the semi-structured interviews, and finally the observation group. Through the survey, many of the participants expressed that filters could have influenced the data collection within the SBS 2035 project. But most of them were neutral on the ability of machines to surpass humans in detecting of weak signals.

From the thematic analysis of the interviews, participants expressed that the volume of today's data is very vast. This makes it challenge to sift through it to locate the relevant information. The participants were of the opinion that the ML output was very basic and lacked the depth to make meaningful interpretation. Though participants expressed that potentially ML models could overcome the filters of weak signals, these were personal views and aimed at the future rather than the present. Also, participants expressed that filters will always remain regardless of ML.

In observation, fatigue and pressure led participants to not think comprehensively. And the perception of WS differed based on the personal circumstances of the participants. Further, the observation group participants expressed that information might be rejected due to perceived threat to one's position or wishful thinking. In the next chapter, analysis from case 2 will be presented.

9. Data analysis Case 2

The details of this case study were provided in chapter 7. In this case study, data was collected using Miro³ board observations and semi-structured interviews. The interviews were analysed using thematic analysis. The machine learning outputs were used in Miro board analysis and semi-structured interviews.

9.1. Data analysis – semi structured interviews

Three EIBE students agreed to being interviewed. As mentioned in the data collection chapter, the students were interviewed virtually on zoom. The transcripts were generated automatically by Zoom. The transcripts were checked for errors and imported to Nvivo for analysis. After reading the transcripts, the researcher could see that the codes from case 1 could be used. Once the coding was completed, the codes were analysed for themes using thematic analysis. These were possible as the interview protocol was the same as case 1 but the questions were tailored to suit the EMBA students who were working executives.

The following table shows the themes and the respective occurrences. The first column is the theme. And the following table are interviews named as alphabets.

³ Miro board is a digital collaboration tool, imitating the in-person white board and post-it notes collaboration. More information can be found here: <https://miro.com/>

Table 32: Coding matrix, case 2

| | A | B | C |
|------------------------|---|---|---|
| ML as starting point | 2 | 1 | 1 |
| ML data concerns | 0 | 0 | 1 |
| ML negative attributes | 0 | 1 | 1 |

ML as starting point

This was the strongest theme with all three participants expressing that they felt that ML output would be a good starting point in scanning for weak signals. The cluster of words from the ML output would act as a guide or keywords to enable participants to scan for drivers and weak signals. An excerpt from an interview is presented below:

"... it would seriously help me a lot because first I'm new to me, this is my first time doing it (scenario planning). And this kind of keyword actually will trigger me to think and come up with a... what to say... when I wanted to do some research or when I wanted to find... I will actually see all these

keywords. Which are important keywords for the specific country, I mean okay Constitution, government, fast, national figure is all the real key words that you need” (P2A21, Interviews 2021).

ML negative attributes

Though all the participants expressed that ML would be a good starting point, they also expressed that it would not be of much help within a group setting. As cluster of words is open to subjective interpretations. Which might lead to a negative influence on team dynamics. This was counterintuitive to the previous theme. Excerpts from the interview is presented below.

“The major challenge will be different perspectives [of] people not being able to interpret things in the same way” (P2B21, Interviews 2021).

“To [me] they're just... they're not quite as descriptive as I would want. Because you know... single words... and it could mean anything in any context. So just looking at this alone one can't really make any real influence...” (P2B21, Interviews 2021).

Though the first theme, 'ML as a starting point', was expressed by the three participants, the usability or feasibility of the ML output was questioned. Thus, leading to a contradiction. Additionally, the subjective interpretation of the ML output would be influenced by various inherent human biases which would amplify the filters. Thus, though there is a possibility of ML to aid scanners as a starting point, there seems to be a possibility that ML cannot enhance weak signal detection. Also, the subjective interpretation of the ML output seems to amplify the filters whilst perceiving it.

The second part of this case study was the analysis of Miro boards of EIBE students. A total of 12 Miro boards were analysed and the analysis and discussions are presented in the next section.

9.2. Data analysis process – Miro board observation

The Miro boards (hereafter referred as just boards) of executive MBA student groups from the EIBE course was used as a data source for making comparisons of the manual method with that of machine learning output. For accessing the boards, permission from the EIBE MBA students from the executive centres of Strathclyde was sought. The researcher received access to thirteen boards in total. As mentioned in one of the earlier sections where the EIBE course was introduced, the boards belonged to one of the six countries – Argentina, Bolivia, Chile, Peru, Paraguay, and Uruguay. The following table 33 shows the number of samples that were analysed.

Table 33: EIBE country and no. of boards

| Country Name | No. of Boards |
|---------------------|----------------------|
| Argentina | 2 |
| Bolivia | 2 |
| Chile | 3 |
| Paraguay | 2 |
| Peru | 2 |
| Uruguay | 1 |
| Total | 12 |

A machine learning (ML) model was run for each of the country based on the method described earlier. The ML output was a list of topics for each case. But the topics were not labelled but it was a cluster of words based on the pattern recognised by the ML model. It was practically not possible to ask the respective MBA teams to label the ML output to enable the researcher to make comparisons between the output of ML model with that of the MBA team output. But it was important to make meaningful comparisons between the outputs generated by the teams and the ML model.

Another challenge whilst making comparisons was that the drivers detected by MBA students were subjective. That is, a driver would be worded differently but carry the same essence and meaning. Thus, it was impossible to make a direct comparison with the output of the machine learning model. Hence, the labelling method for the topic output from the machine learning had to be flexible and broad to accommodate the subjectivity outlined previously.

Another challenge that the researcher was presented with was that even though machine learning, especially LDA (Latent Dirichlet Allocation), had been used to detect weak signals and drivers, none of those papers (For e.g., see: El Akrouchi, Benbrahim and Kassou, 2021) had made a comparison between human detected drivers and machine detected outputs. Most of the papers in the literature either used machine as part of a foresight project or to automate driver detection. But the ability of ML to detect weak signals was always done in retrospect. Thus, the researcher had to innovatively develop a method for labelling the machine learning output which would facilitate a comparison of the ML output with that of drivers detected by MBA students.

Table 34: Example ML output

| word | word1 | word2 | word | word | word | word | word | word | word |
|-------------|--------------|--------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| 0 | | | 3 | 4 | 5 | 6 | 7 | 8 | 9 |

| | | | | | | | | | |
|-------|-----------------|---------------|------------|------|-------|--------------|------------|------------|-------|
| trade | developm ent | educati on | growt h | page | first | busine ss | mark et | acces s | covid |
|-------|-----------------|---------------|------------|------|-------|--------------|------------|------------|-------|

To achieve this, the label of the ML output was coded as generic keywords instead of giving one label. For example, the extract of output of ML is shown in table 34. This was coded as "trade & economic development/ covid & economy". This code was assigned a unique single digit for the ease of coding the drivers detected by the MBA students. The "/" symbol within the code corresponds to the "or" or "and" logic. Only the labels from the ML output were then copied and pasted on to an excel file. Within this file, a unique number (code) was assigned to each label. It should be noted that the uniqueness was limited only to one case. One Excel file containing the labels and code was created for each case. This file was used to map drivers from each and every sample within each of the case with that of the machine learning output.

For mapping the drivers, the drivers generated by the MBA students from the Miro board were downloaded to an excel file. An extract of this excel file is presented here in table 35 and a partially bigger example is presented in the appendix. The list of drivers in each of the sample reach more than 100 lines and thus it is impractical to attach all the list in the appendix as each file would consume too many pages making it unreadable.

Table 35: Extract of drivers (MBA students)

| Extract of drivers (MBA students) |
|--|
| The cost of energy for users |
| The level of dependency on natural resources |

| |
|---|
| The level of Co2 emission |
| The effects of an aging population |
| The effect of population growth trends |
| The impact of covid-19 on trade (import & export) |
| The impact of manufacturing |

The only way to map the ML output with that of the drivers from the EIBE course was a subjective and judgemental approach. The ML codes were broad enough to accommodate various versions and extensions from the EIBE drivers. A sample coding is shown below in table 36. A sample output of the machine learning model and the label is show in table 38. A full list of machine learning output for all the cases and its corresponding labels is presented in the appendix.

Table 36: Sample of coding ML output

| Label | Code |
|---|-------------|
| government/ politics/ people and government | 1 |
| investment/ technology | 9 |
| gender and women | 20 |
| geographic/ earthquake | 25 |

The mapping and matching of the drivers generated by the MBA students with that of the code was done by the good judgement of the researcher. The researcher would go line by line of each driver (generated by MBA students) and map it to the code of the ML output. Table 37 shows the sample coding of drivers generated by MBA student with that of the ML output (please refer table 36). This subjective mapping was done as the labelling of the drivers by the MBA students was a subjective exercise. Further this label of the driver was the summary from what the particular student could deduce and interpret from the original information source.

Table 37: Mapping of MBA drivers to ML drivers

| MBA student Driver | Mapped to ML driver by code |
|--|------------------------------------|
| the levels of access to highspeed internet | 9 |

| | |
|---|----|
| No of women in corporate management | 20 |
| The occurrence of Natural disasters | 25 |
| The outcome of impact of change in government | 1 |

Figure 41 shows the step by step process of how the mapping was done for each of the EIBE country.

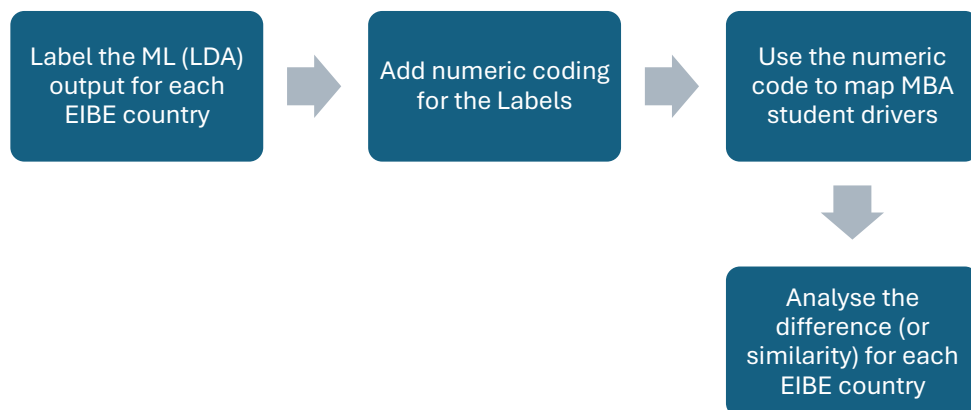


Figure 42: Steps of mapping drivers

Table 38: Sample ML output with label

| word 0 | word 1 | word 2 | word 3 | word 4 | word 5 | word 6 | word 7 | word 8 | word 9 | word 10 | word 11 | Label |
|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|------------|------------|------------|--|
| show | month | day | high | life | based | partner | activity | help | corruption | | | corruption related |
| include | know | political | impact | power | well | local | state | public | partner | | | political/ public partnership / state vs central/ political impact |
| social | home | today | covid | national | effort | land | million | people | corruption | | | corruption/ covid/ public affected |

| | | | | | | | | | | | | |
|-----------------|-----------|-----------------|-----------------------|-----------------|----------|----------|-----------|---------------|-------------|----------|-------------|--|
| am eri ca | lati n | am eri ca | parti cipati on | im pro ve | fin d | wo rk | loc al | so ut h | ame rica | ma ke | des pite | work avai lability/j ob avai lability/ impro ving work oppor tunity / ameri ca and latina ameri ca partici pation |
|-----------------|-----------|-----------------|-----------------------|-----------------|----------|----------|-----------|---------------|-------------|----------|-------------|--|

For analysing the machine learning output's acceptability, each of the samples from each of the case was coded (extract of this is shown in table 37). Not all the drivers from a sample could be mapped using the codes. Thus, when a driver could not be mapped with a code this would imply that the machine has missed detecting that driver. Similarly, if a code did not appear mapped to a driver within a sample, this would imply that the MBA students have missed a particular driver. The researcher made notes of these differences to answer the research questions laid out in the earlier chapters.

The analysis on each of the case will be presented in the following sections. It should be noted that the Miro boards containing the drivers for each of the case cannot be presented within this thesis as they are interactive boards. And these boards (replica of a white board with various information) are usually very large and cannot be copied and pasted for accurate representation. Some access restriction also restricts copying content. Furthermore, by attempting to present all the boards here there is a risk of breaching the protection assured to the participants by the researcher. The participants were assured of anonymity and confidentiality by the researcher through the researcher's participant information and consent statement. Thus, representative screenshots of the Miro boards have been presented in the appendix.

9.2.1. Argentina

A total of two sample were analysed for this country. Tables 39 and 40 shows the ML output and the frequency of that topic appearing in the sample. A visual representation of this is presented as a bar graph in figure 42 and figure 43.

Table 39: Argentina1 ML label

| Code Unique Number | Code | Number of times code occurred |
|--------------------------|--|-------------------------------------|
| 1 | clothing range/ consumer pattern/ research | 1 |
| 2 | education / level of education | 1 |
| 3 | study / approach to study/ research | 0 |
| 4 | population/ social analysis | 10 |
| 5 | event analysis/ research | 0 |
| 6 | species/ environment/ change climate | 5 |
| 7 | climate change | 4 |
| 8 | environment/ forest/ region | 4 |
| 9 | export/ commerce/ trade | 0 |
| 10 | covid strategy/ covid support/ development | 1 |
| 11 | emphasis on trade/ sector performance/ market strategy | 0 |
| 12 | challenges with system/ people/ leadership | 9 |
| 13 | problem with work/ national vaccinations/ | 1 |
| 14 | economic performance/ economic policy performance | 18 |
| 15 | regional healthcare/ covid/ covid vaccine | 5 |
| 16 | population/ covid strategy/ funding for managing health | 6 |
| 17 | debt servicing/ investments/ | 10 |
| 18 | American influence/ global approach/ historical relations | 12 |

| | | |
|----|---|----|
| 19 | voting/ legislature | 1 |
| 20 | government vaccination/ people getting vaccinated | 0 |
| 21 | covid death/ covid life | 0 |
| 22 | football | 1 |
| 23 | inflation/ economy/ effect from Venezuela | 11 |

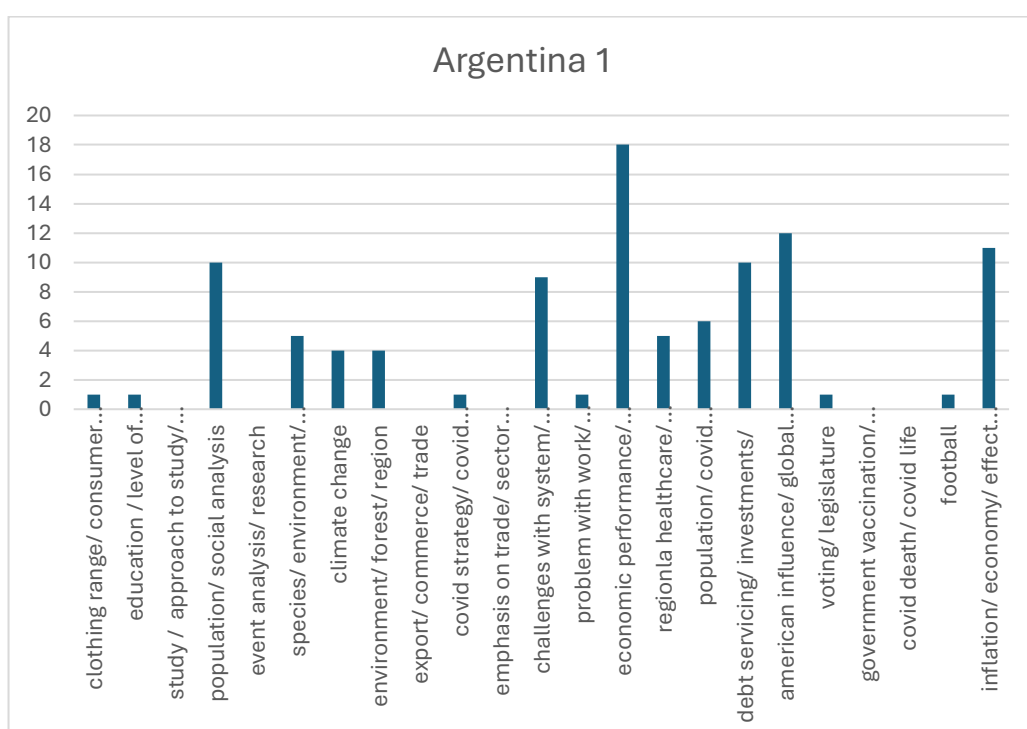


Figure 43: Argentina 1

Table 40: Argentina 2 ML label

| Code Unique Number | Code | Number of times code occurred |
|--------------------------|--|--|
| 1 | clothing range/ consumer pattern/ research | 0 |

| | | |
|----|---|----|
| 2 | education / level of education | 2 |
| 3 | study / approach to study/ research | 0 |
| 4 | population/ social analysis | 14 |
| 5 | event analysis/ research | 0 |
| 6 | species/ environment/ change climate | 3 |
| 7 | climate change | 2 |
| 8 | environment/ forest/ region | 0 |
| 9 | export/ commerce/ trade | 5 |
| 10 | covid strategy/ covid support/ development | 0 |
| 11 | emphasis on trade/ sector performance/ market strategy | 0 |
| 12 | challenges with system/ people/ leadership | 3 |
| 13 | problem with work/ national vaccinations/ | 0 |
| 14 | economic performance/ economic policy performance | 5 |
| 15 | regional healthcare/ covid/ covid vaccine | 2 |
| 16 | population/ covid strategy/ funding for managing health | 4 |
| 17 | debt servicing/ investments/ | 3 |
| 18 | American influence/ global approach/ historical relations | 0 |
| 19 | voting/ legislature | 2 |
| 20 | government vaccination/ people getting vaccinated | 0 |
| 21 | covid death/ covid life | 1 |
| 22 | football | 0 |
| 23 | inflation/ economy/ effect from Venezuela | 1 |

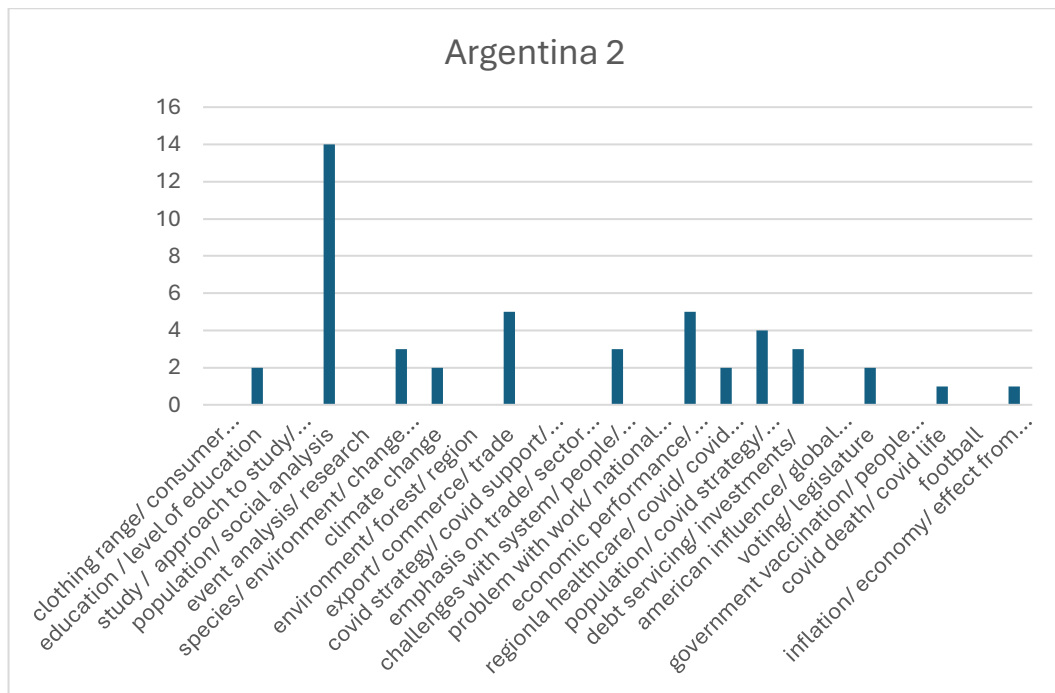


Figure 44: Argentina 2

From figures 42 & 43 it can be seen that the students did miss some drivers that the machine has detected. But when both samples are looked at together, students have only missed 4 drivers. The machine has also failed to detect some of the drivers detected by the students such as, crime related topics, energy, industry & commerce, technology, mining, education related, etc. The machines have missed detecting drivers more than that the humans have detected. Table 41 below shows the drivers missed by students when combined. In the column 'Sample 1' and 'Sample 2', '0' indicates drivers not detected by students.

Table 41: Drivers missed by students (combined) Argentina

| Code Unique Number | Code | Sample 1 | Sample 2 |
|--------------------|------|----------|----------|
| | | | |

| | | | |
|----|---|---|---|
| 3 | study / approach to study/ research | 0 | 0 |
| 5 | event analysis/ research | 0 | 0 |
| 11 | emphasis on trade/ sector performance/ market strategy | 0 | 0 |
| 20 | government vaccination/ people getting vaccinated | 0 | 0 |

9.2.2. Bolivia

There were two samples within the Bolivia case. Like the previous case, some drivers were missed by the students which were detected by the machine. When both the samples were combined, the students missed 8 drivers that the machine detected: gender/ poverty & challenges/ covid challenge; South American cooperation/ cocoa partnership; geography/ volcanic/ slat; supply chain/ volcano; tax & accounting legal issues/ Luxembourg, Belgium, Lithuania, and Germany influence; evo racing/ motorsports; political coup; Peru and Bolivia. Table 42 below shows the drivers missed by students when combined. In the column 'Sample 1' and 'Sample 2', '0' indicates drivers not detected by students.

Table 42: Drivers missed by students - Bolivia

| Code | Label | Sample 1 | Sample 2 |
|-------------|--|---------------------|---------------------|
| 10 | gender/ poverty & challenges/ covid challenge | 0 | 0 |
| 12 | south american cooperation/ cocoa partnership | 0 | 0 |
| 16 | geography/ volcanic/ slat | 0 | 0 |
| 17 | supply chain/ volcano | 0 | 0 |
| 25 | tax & accounting legal issues/ luxembourg, belgium, lithuania, and germany influence | 0 | 0 |
| 26 | evo racing/ motorsports | 0 | 0 |
| 27 | political coup | 0 | 0 |
| 28 | peru and bolivia | 0 | 0 |

The tables 43 and 44 show the ML topic and the frequency of its occurrence. Figure 44 and 45 shows the graphical representation of table 43 and 44.

At the same time, the machine failed to detect some of the drivers that were detected by the MBA students. In total 8 drivers were missed by the machine: emissions & energy, innovation policy, digitalisation, corruption, labour, agriculture, tourism, education, etc.

Table 43: Bolivia ML label

| Label | Number of times code occurred |
|---|-------------------------------|
| farmer/farming support/ community working/ community help | 3 |
| population/population diversity/ population analysis | 3 |
| crime/ violence | 7 |
| schooling/ community upliftment programmes/ bringing about change/ support for upliftment | 9 |
| governance/ government income/ presidential trend | 4 |
| indigenous people law/ water in relation to indigenous | 1 |
| tax generation/ coca economy/ international and global influence on economy | 2 |
| tax/income for government/ regional government income | 2 |
| amazon/climate effects/ economic | 8 |
| gender/ poverty & challenges/ covid challenge | 0 |
| justice & rights/ financial measures | 4 |
| south American cooperation/ cocoa partnership | 0 |
| politics/ governance | 2 |
| regional culture/ work/ government support | 2 |
| culture/food/ culture & food & population | 2 |
| geography/ volcanic/ slat | 0 |
| supply chain/ volcano | 0 |
| Andes ecosystem/water | 1 |
| water & ground water/ water resources/ effect of population & water | 6 |
| natural resource distribution and dependence/ natural resources & economy & politics | 6 |
| lithium mining/ lithium effect on ecosystem/ | 2 |

| | |
|--|---|
| women social & policy | 7 |
| covid & healthcare | 4 |
| vaccine issues | 1 |
| tax & accounting legal issues/ Luxembourg, Belgium, Lithuania, and Germany influence | 0 |
| evo racing/ motorsports | 0 |
| political coup | 0 |
| Peru and Bolivia | 0 |
| south American countries influence | 1 |

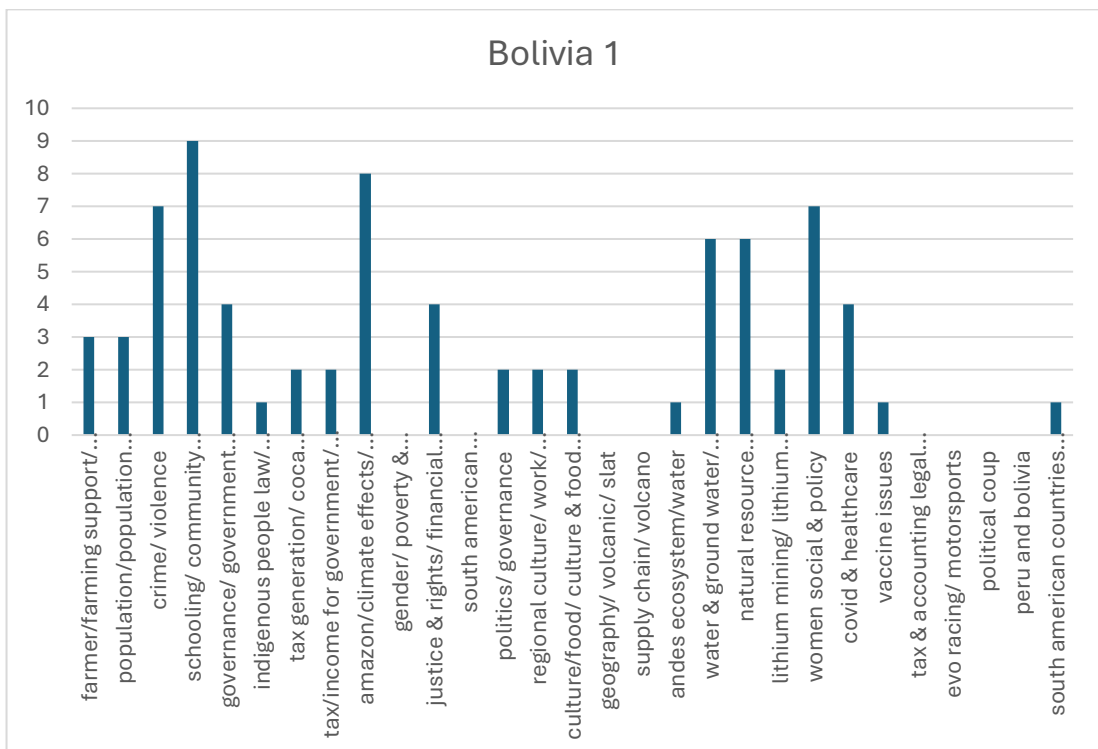


Figure 45: Bolivia 1

Table 44: Bolivia 2 ML label

| Label | |
|---|---|
| farmer/farming support/ community working/ community help | 4 |
| population/population diversity/ population analysis | 2 |
| crime/ violence | 1 |
| schooling/ community upliftment programmes/ bringing about change/ support for upliftment | 6 |
| governance/ government income/ presidential trend | 0 |
| indigenous people law/ water in relation to indigenous | 2 |
| tax generation/ coca economy/ international and global influence on economy | 2 |
| tax/income for government/ regional government income | 2 |
| amazon/climate effects/ economic | 3 |
| gender/ poverty & challenges/ covid challenge | 0 |
| justice & rights/ financial measures | 9 |
| south american cooperation/ cocoa partnership | 0 |
| politics/ governance | 3 |
| regional culture/ work/ government support | 0 |
| culture/food/ culture & food & population | 0 |
| geography/ volcanic/ slat | 0 |
| supply chain/ volcano | 0 |
| andes ecosystem/water | 0 |
| water & ground water/ water resources/ effect of population & water | 2 |
| natural resource distribution and dependence/ natural resources & economy & politics | 6 |
| lithium mining/ lithium effect on ecosystem/ | 2 |
| women social & policy | 3 |
| covid & healthcare | 1 |
| vaccine issues | 0 |

| | |
|--|---|
| tax & accounting legal issues/ luxembourg, belgium, lithuania, and germany influence | 0 |
| evo racing/ motorsports | 0 |
| political coup | 0 |
| peru and bolivia | 0 |
| south american countries influence | 0 |

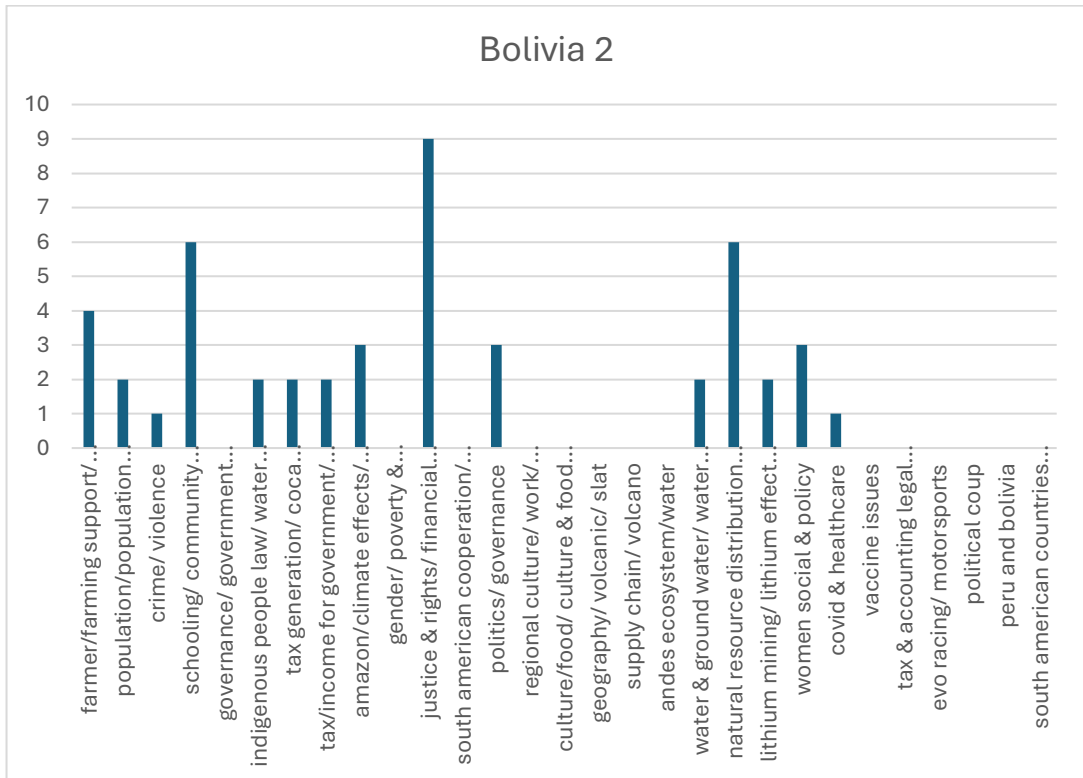


Figure 46: Bolivia 2

Overall, as with the previous case, some drivers were missed by the machine learning algorithm and some by human based scanning.

9.2.3. Chile

A total of four samples were available for this case. Tables 45, 46, & 47 show the ML output for Chile and the frequency of its occurrence for each of the sample for Chile. Figures 46, 47, & 48 show the graphical representation.

As individual samples (teams), the students missed some drivers that the machine has detected. For example, water & South America, covid / pandemic related issues, etc. But when all the three samples were considered together, then all the drivers detected by the machines were detected by humans. However, the machine missed drivers such as: Human rights issues, Influence of international conflicts, Infrastructure issues, Legal and crime related, Manufacturing, and Natural resources.

Table 45: Chile ML label

| Code | Label | Number of times code occurred |
|------|---|-------------------------------|
| 1 | government/ politics/ people and government | 7 |
| 2 | trade & economic development/ covid and economy | 4 |
| 3 | investment/ captial region economy | 2 |
| 4 | latina american trade | 1 |
| 5 | environmental | 3 |
| 6 | covid related | 0 |
| 7 | water and south america | 0 |
| 8 | trade and market related/ tax related | 7 |
| 9 | investment/ technology | 8 |
| 10 | education/economy | 1 |
| 11 | water/captial region/ water related | 6 |
| 12 | trade policy | 2 |

| | | |
|----|---|----|
| 13 | tourism | 2 |
| 14 | tax & political problems/ presidential problems | 6 |
| 15 | business | 1 |
| 16 | covid and economy | 1 |
| 17 | trade development/ economic policy | 10 |
| 18 | covid related issues/pandemic related issues | 0 |
| 19 | healthcare/ disease control & risk | 7 |
| 20 | gender and women | 8 |
| 21 | education | 5 |
| 22 | higher education | 1 |
| 23 | political analysis | 1 |
| 24 | cost of energy/ emission | 10 |
| 25 | geographic/ earthquake | 6 |
| 26 | urban pollution | 9 |
| 27 | fish/ food related | 1 |
| 28 | climate change | 4 |
| 29 | travel to chile related | 1 |
| 30 | captial region politics/ communist | 1 |

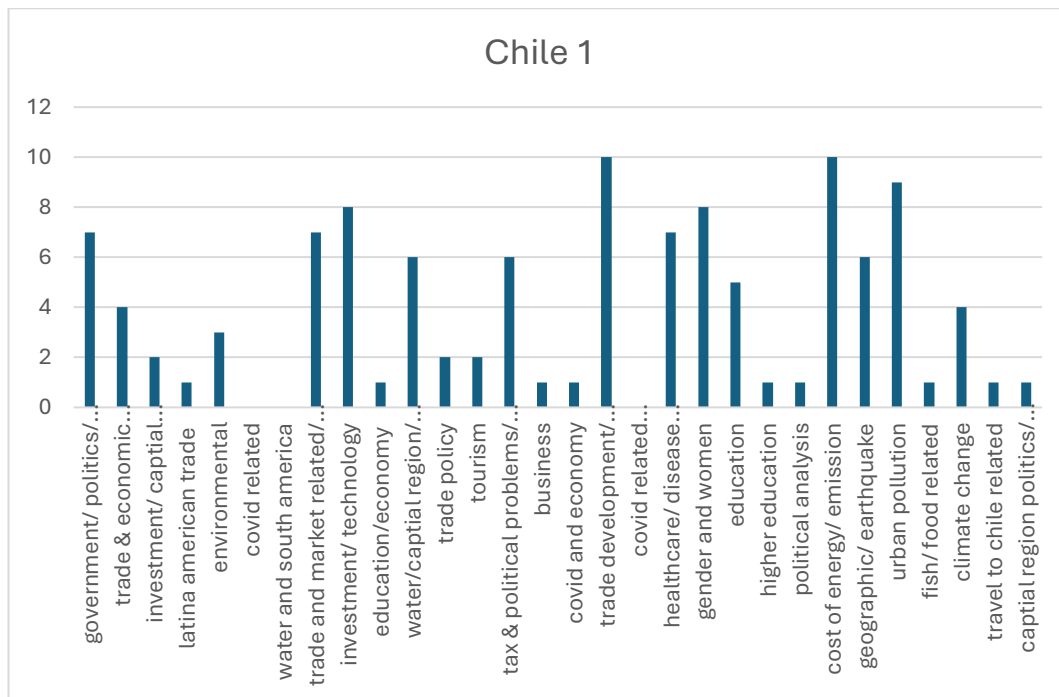


Figure 47: Chile 1

Table 46: Chile 2 ML label

| Code | Label | |
|------|---|---|
| 1 | government/ politics/ people and government | 1 |
| 2 | trade & economic development/ covid and economy | 0 |
| 3 | investment/ captial region economy | 0 |
| 4 | latina american trade | 2 |
| 5 | environmental | 2 |
| 6 | covid related | 1 |
| 7 | water and south america | 0 |
| 8 | trade and market related/ tax related | 1 |
| 9 | investment/ technology | 5 |
| 10 | education/economy | 0 |
| 11 | water/captial region/ water related | 2 |

| | | |
|----|---|---|
| 12 | trade policy | 1 |
| 13 | tourism | 2 |
| 14 | tax & political problems/ presidential problems | 4 |
| 15 | business | 0 |
| 16 | covid and economy | 2 |
| 17 | trade development/ economic policy | 5 |
| 18 | covid related issues/pandemic related issues | 2 |
| 19 | healthcare/ disease control & risk | 4 |
| 20 | gender and women | 3 |
| 21 | education | 6 |
| 22 | higher education | 1 |
| 23 | political analysis | 0 |
| 24 | cost of energy/ emission | 3 |
| 25 | geographic/ earthquake | 3 |
| 26 | urban pollution | 2 |
| 27 | fish/ food related | 0 |
| 28 | climate change | 3 |
| 29 | travel to chile related | 0 |
| 30 | captial region politics/ communist | 0 |

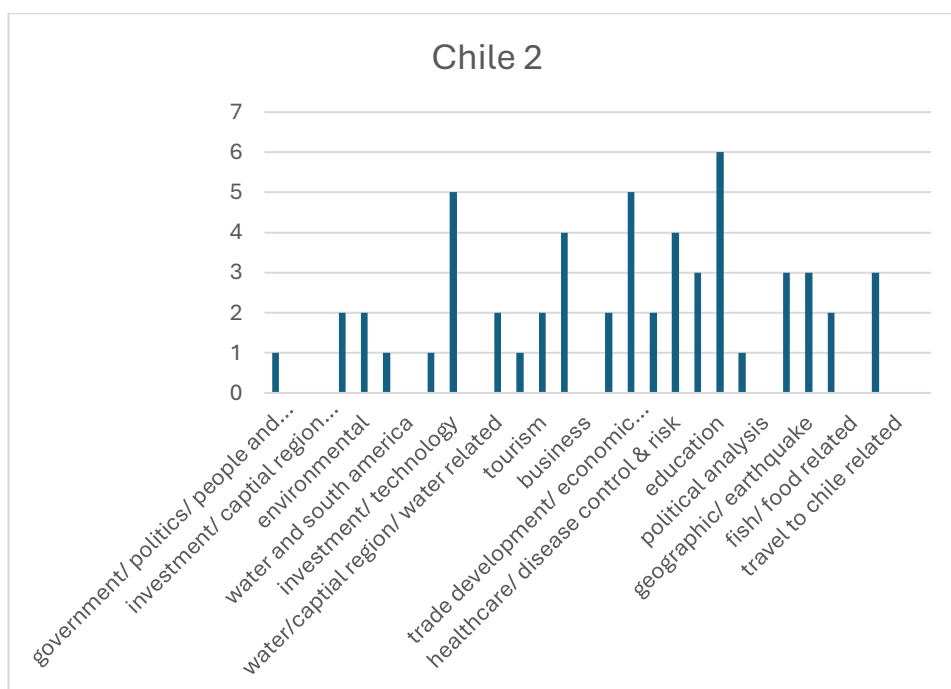


Figure 48: Chile 2

Table 47: Chile 3 ML label

| Code | Label | |
|------|---|---|
| 1 | government/ politics/ people and government | 4 |
| 2 | trade & economic development/ covid and economy | 2 |
| 3 | investment/ capital region economy | 2 |
| 4 | latina american trade | 2 |
| 5 | environmental | 0 |
| 6 | covid related | 2 |
| 7 | water and south america | 2 |
| 8 | trade and market related/ tax related | 3 |
| 9 | investment/ technology | 9 |
| 10 | education/economy | 2 |
| 11 | water/capital region/ water related | 2 |
| 12 | trade policy | 3 |

| | | |
|----|---|----|
| 13 | tourism | 5 |
| 14 | tax & political problems/ presidential problems | 3 |
| 15 | business | 1 |
| 16 | covid and economy | 0 |
| 17 | trade development/ economic policy | 8 |
| 18 | covid related issues/pandemic related issues | 0 |
| 19 | healthcare/ disease control & risk | 10 |
| 20 | gender and women | 1 |
| 21 | education | 10 |
| 22 | higher education | 1 |
| 23 | political analysis | 0 |
| 24 | cost of energy/ emission | 9 |
| 25 | geographic/ earthquake | 2 |
| 26 | urban pollution | 1 |
| 27 | fish/ food related | 0 |
| 28 | climate change | 3 |
| 29 | travel to chile related | 0 |
| 30 | capital region politics/ communist | 2 |

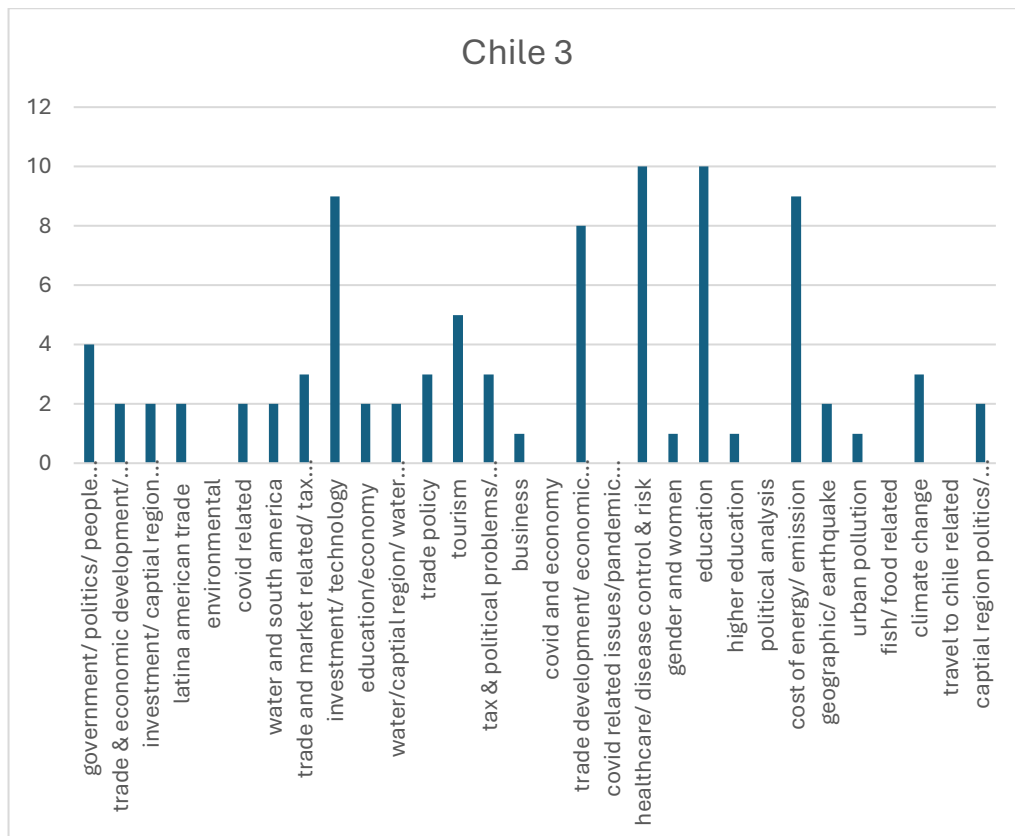


Figure 49: Chile 3

Overall, the machine missed some of the drivers, but the students (combined) did not miss any drivers that were detected by the machines.

9.2.4. Paraguay

In the case of Paraguay, two samples were analysed. Tables 49 & 50 shows the driver and the frequency with which it has occurred in each of the sample respectively. Figures 49 & 50 show the tables in a graphical format. Similar to the previous cases, here too the students have missed some of the drivers detected by the machine. For example, some of the drivers missed by the students are, effectiveness of the law, long war, corruption, effects of pandemic, community role in trade, border issues, environment / water resources, changes to the Andes range, etc. Even when the two samples

were combined, in total, the students missed of 16 drivers. This was higher than the drivers missed by students in the previous samples. Table 48 below shows the drivers missed by students when combined. In the column 'Sample 1' and 'Sample 2', '0' indicates drivers not detected by students.

Table 48: Drivers missed by students - Paraguay

| Code | Label | Sample 1 | Sample 2 |
|------|--|----------|----------|
| 6 | law support and effect on economy | 0 | 0 |
| 7 | effects of long war on population and lives | 0 | 0 |
| 10 | effect of global and pandemic/ | 0 | 0 |
| 20 | football or other play | 0 | 0 |
| 21 | people sentiment for the country | 0 | 0 |
| 22 | covid vaccine encouragement | 0 | 0 |
| 24 | USA/ teaming up with USA | 0 | 0 |
| 25 | football | 0 | 0 |
| 26 | regional demographics and history | 0 | 0 |
| 28 | covid effect on USA and COVID's impact on paraguay | 0 | 0 |
| 29 | health/ covid effects/ | 0 | 0 |
| 30 | environment/ water resource monitoring | 0 | 0 |
| 31 | effects of water resource and associated risk | 0 | 0 |
| 32 | research and analysis | 0 | 0 |
| 33 | changes to the andes range | 0 | 0 |
| 34 | social changes and change process | 0 | 0 |

The machine too missed some drivers that were identified by the students. Some of the missed drivers are: crime, energy, nuclear, human rights & freedom, technology, climate change, titanium deposits / natural resources. Thus, machines were able to detect more drivers than humans.

Table 49: Paraguay ML label

| Code | Label | |
|------|---|---|
| 1 | national security/ crime/ official response | 3 |
| 2 | corruption related | 2 |
| 3 | political/ public partnership/ state vs central/ political impact | 5 |
| 4 | corruption/ covid/ public affected | 0 |
| 5 | work availability/job availability/ improving work opportunity/ america and latina america participation | 0 |
| 6 | law support and effect on economy | 0 |
| 7 | effects of long war on population and lives | 0 |
| 8 | access to development/ development of areas for community and income upliftment | 0 |
| 9 | eradication of corruption | 0 |
| 10 | effect of global and pandemic/ | 0 |
| 11 | agricultural policy/ land and agriculture working/ agricultural policy | 5 |
| 12 | need for infrastructure/ important to develop capital region/ | 3 |
| 13 | presidential actions/ regional economy/ | 0 |
| 14 | export/ trade/ | 1 |
| 15 | production and trade/ improve trade/ community and public role in trade | 0 |
| 16 | trade relations with brazil/ effect of pandemic economically | 1 |
| 17 | financial system/ trade relations with the US | 1 |
| 18 | resources for pandemic/ future impact of pandemic on people | 1 |
| 19 | social and population impact | 3 |
| 20 | football or other play | 0 |
| 21 | people sentiment for the country | 0 |
| 22 | covid vaccine encouragement | 0 |
| 23 | border and cities issues | 0 |
| 24 | USA/ teaming up with USA | 0 |

| | | |
|----|--|---|
| 25 | football | 0 |
| 26 | regional demographics and history | 0 |
| 27 | river/ captial region | 0 |
| 28 | covid effect on USA and COVID's impact on paraguay | 0 |
| 29 | health/ covid effects/ | 0 |
| 30 | environment/ water resource monitoring | 0 |
| 31 | effects of water resource and associated risk | 0 |
| 32 | research and analysis | 0 |
| 33 | changes to the andes range | 0 |
| 34 | social changes and change process | 0 |

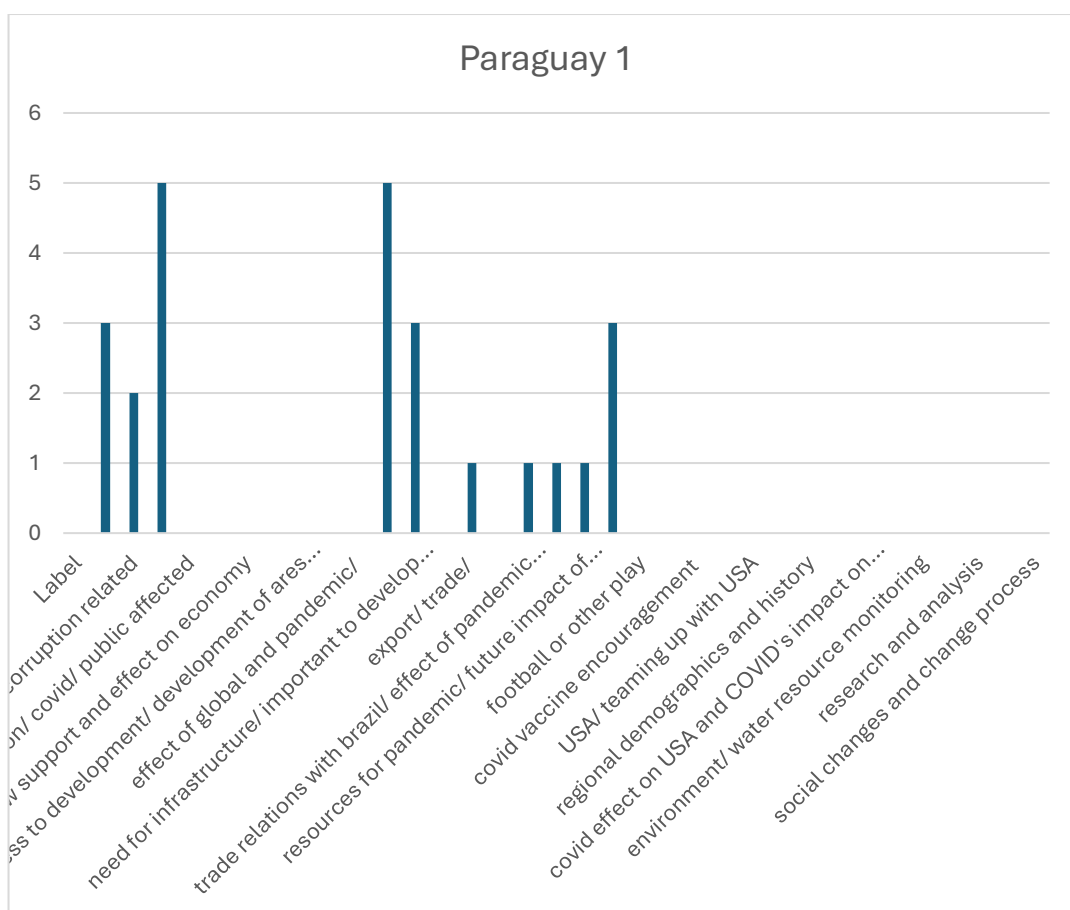


Figure 50: Paraguay 1

Table 50: Paraguay 2 ML label

| Code | Label | |
|------|--|----|
| 1 | national security/ crime/ official response | 3 |
| 2 | corruption related | 0 |
| 3 | political/ public partnership/ state vs central/ political impact | 6 |
| 4 | corruption/ covid/ public affected | 1 |
| 5 | work availability/job availability/ improving work opportunity/ america and latina america participation | 3 |
| 6 | law support and effect on economy | 0 |
| 7 | effects of long war on population and lives | 0 |
| 8 | access to development/ development of ares for community and income upliftment | 5 |
| 9 | eradication of corruption | 1 |
| 10 | effect of global and pandemic/ | 0 |
| 11 | agricultural poligy/ land and agriculture working/ agricultural policy | 14 |
| 12 | need for infrastructure/ important to develop capital region/ | 3 |
| 13 | presidential actions/ regional economy/ | 2 |
| 14 | export/ trade/ | 3 |
| 15 | production and trade/ improve trade/ community and public role in trade | 4 |
| 16 | trade relations with brazil/ effect of pandemic economically | 1 |
| 17 | financial system/ trade relations with the US | 1 |
| 18 | resources for pandemic/ future impact of pandemic on people | 2 |
| 19 | social and population impact | 4 |
| 20 | football or other play | 0 |

| | | |
|----|--|---|
| 21 | people sentiment for the country | 0 |
| 22 | covid vaccine encouragement | 0 |
| 23 | border and cities issues | 1 |
| 24 | USA/ teaming up with USA | 0 |
| 25 | football | 0 |
| 26 | regional demographics and history | 0 |
| 27 | river/ capitial region | 1 |
| 28 | covid effect on USA and COVID's impact on paraguay | 0 |
| 29 | health/ covid effects/ | 0 |
| 30 | environment/ water resource monitoring | 0 |
| 31 | effects of water resource and associated risk | 0 |
| 32 | research and analysis | 0 |
| 33 | changes to the andes range | 0 |
| 34 | social changes and change process | 0 |

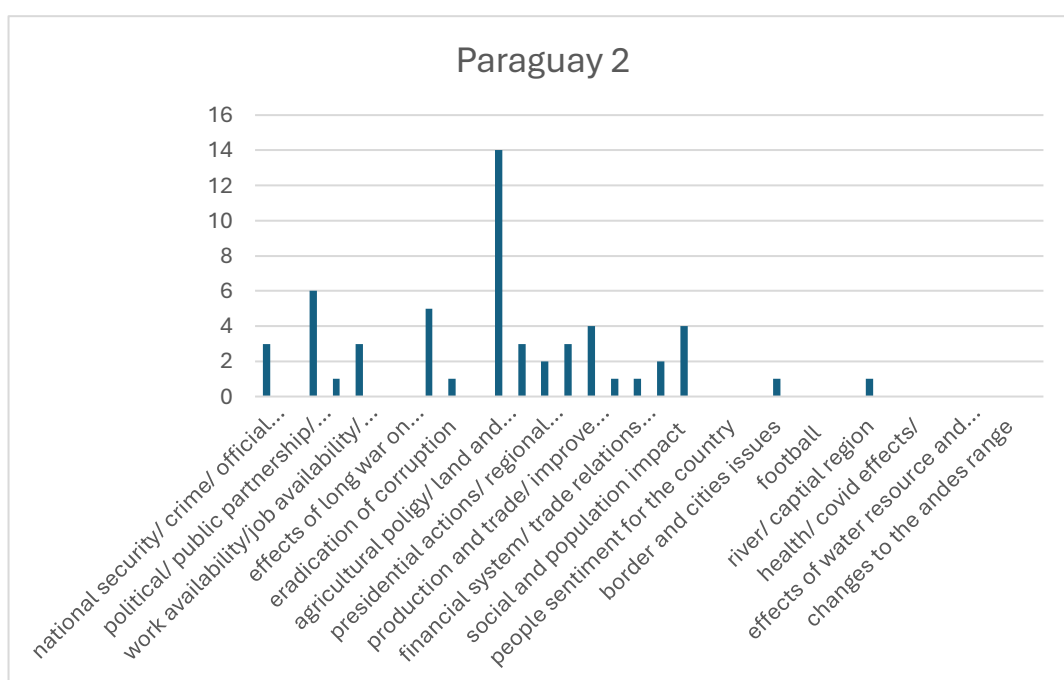


Figure 51: Paraguay 2

Overall, in this case, the machines seem to have detected more drivers than humans, and at the same time, it has missed some as well.

9.2.5. Peru

For the case – Peru, two samples were analysed. Table 52 & 53 shows the ML topic output and the corresponding frequency that a topic appeared in the sample. Figures 51 & 52 shows graphical representation of the tables.

Similar to previous cases, some of the drivers detected by machine were missed by the students. For example, human rights/crime/ justice, geographic and demographic, regional / Latina American economy, etc. But when the two samples were combined, a total of 5 drivers were missed by the students as shown in table 51. In the table, within columns 'Sample 1' and 'Sample 2', '0' indicates drivers not detected by students.

Table 51: Drivers missed by students - Peru

| Code | Label | Sample 1 | Sample 2 |
|-------------|-------------------------------------|-----------------|-----------------|
| 16 | presidents present and past | 0 | 0 |
| 20 | negative peruvian pride | 0 | 0 |
| 23 | geographic and demographic analysis | 0 | 0 |
| 27 | regional and latin american economy | 0 | 0 |
| 29 | geographical analysis and concerns | 0 | 0 |

Similarly, the machine also missed some of the drivers detected by the students. Such as: education, technology & infrastructure, mining, trade, and labour laws.

Table 52: Peru ML label

| Code | Label | |
|------|--|----|
| 1 | political leadership change/ fight for change | 7 |
| 2 | political conflict/ politics/ information and transparency | 10 |
| 3 | president's influence on economy/ market/ projects | 2 |
| 4 | investment in water/ need for investment in water resources | 5 |
| 5 | tourism | 0 |
| 6 | maintainance of nature/ nature preservation/ public private partnership | 7 |
| 7 | regional and american economic opportunities | 4 |
| 8 | tourism | 2 |
| 9 | social development through funding/partnership | 1 |
| 10 | healthcare/ health/ data on health records | 3 |
| 11 | historical | 0 |
| 12 | economy/ economic development/ covid support/ | 8 |
| 13 | gender inequality/ populations related issues | 10 |
| 14 | human rights/ crime/ justice | 0 |
| 15 | corruption | 3 |
| 16 | presidents present and past | 0 |
| 17 | voting related | 2 |
| 18 | people migration | 4 |
| 19 | government/ legal | 2 |
| 20 | negative peruvian pride | 0 |
| 21 | corrput politics/ criminal activities/ need for debates/ need for change | 8 |
| 22 | water and agriculture/ water related problems | 2 |
| 23 | geographic and demographic analysis | 0 |
| 24 | demographics analysis | 13 |
| 25 | geographic analysis and concerns | 5 |
| 26 | problems with fishing industry | 0 |

| | | |
|----|-------------------------------------|---|
| 27 | regional and latin american economy | 0 |
| 28 | climate change, andes change | 2 |
| 29 | geographical analysis and concerns | 0 |

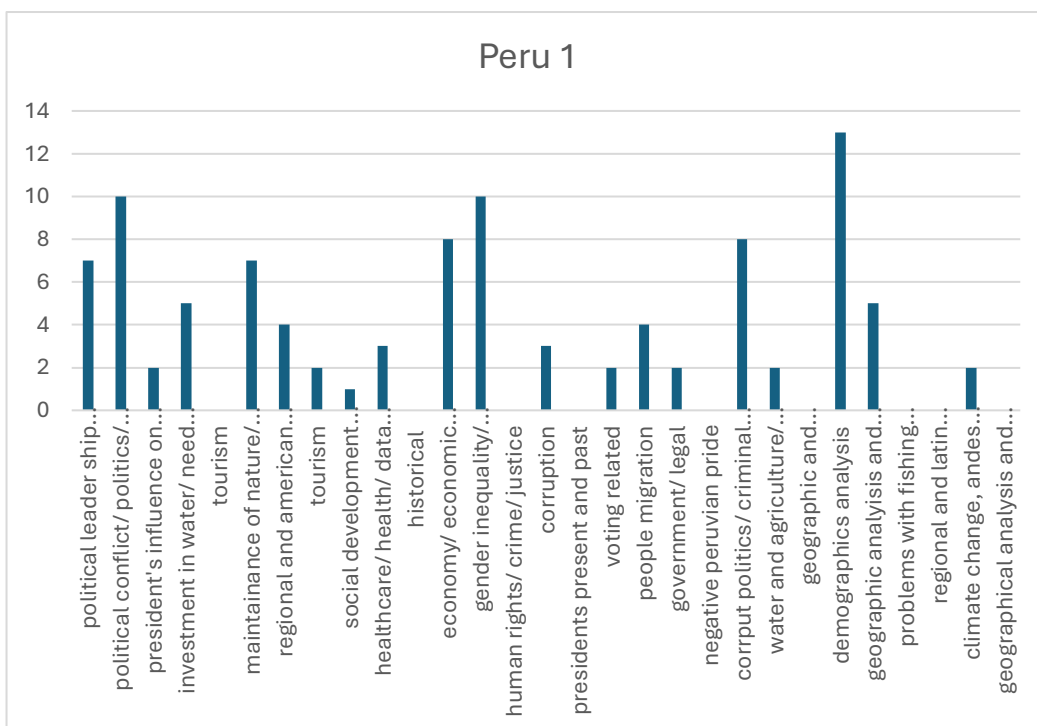


Figure 52: Peru 1

Table 53: Peru 2 ML label

| Code | Label | |
|------|---|---|
| 1 | political leader ship change/ fight for change | 3 |
| 2 | political conflict/ politics/ information and transparency | 2 |
| 3 | president's influence on economy/ market/ projects | 1 |
| 4 | investment in water/ need for investment in water resources | 0 |
| 5 | tourism | 3 |
| 6 | maintainance of nature/ nature preservation/ public private partnership | 1 |

| | | |
|----|---|---|
| 7 | regional and american economic opportunities | 2 |
| 8 | tourism | 5 |
| 9 | social development through funding/partnership | 2 |
| 10 | healthcare/ health/ data on health records | 2 |
| 11 | historical | 1 |
| 12 | economy/ economic development/ covid support/ | 8 |
| 13 | gender inequality/ populations related issues | 7 |
| 14 | human rights/ crime/ justice | 1 |
| 15 | corruption | 0 |
| 16 | presidents present and past | 0 |
| 17 | voting related | 0 |
| 18 | people migration | 1 |
| 19 | government/ legal | 2 |
| 20 | negative peruvian pride | 0 |
| 21 | corrupt politics/ criminal activities/ need for debates/ need for change | 3 |
| 22 | water and agriculture/ water related problems | 3 |
| 23 | geographic and demographic analysis | 0 |
| 24 | demographics analysis | 5 |
| 25 | geographic analysis and concerns | 0 |
| 26 | problems with fishing industry | 1 |
| 27 | regional and latin american economy | 0 |
| 28 | climate change, andes change | 1 |
| 29 | geographical analysis and concerns | 0 |

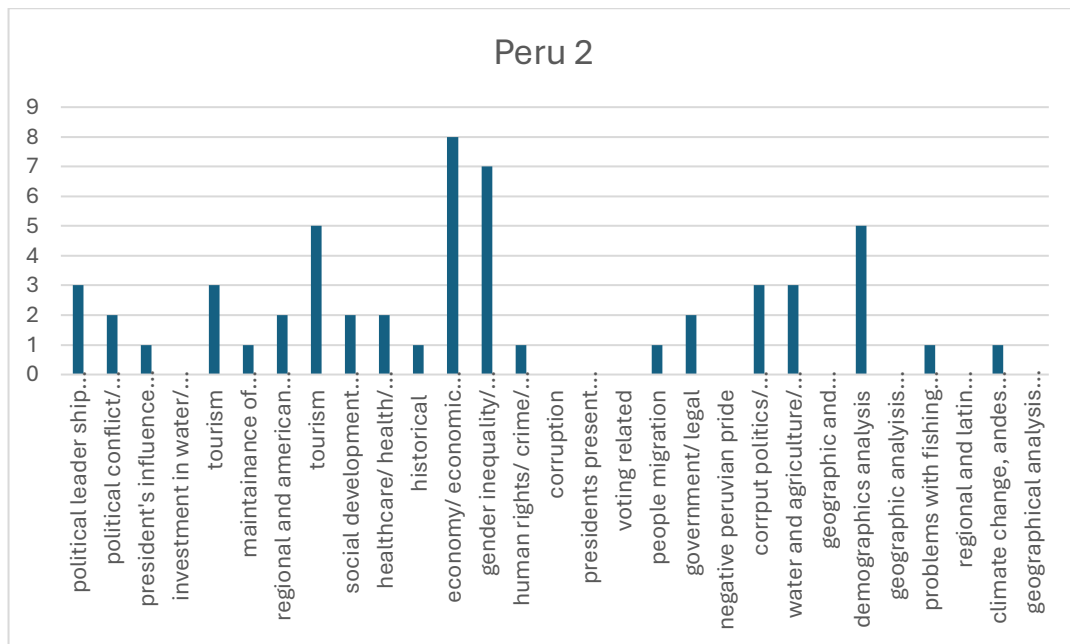


Figure 53: Peru 2

Overall, in the case of Peru the machines missed some drivers detected by students. And similarly, the students missed some of the drivers detected by the machine.

9.2.6. Uruguay

For this case, there was only one sample. Table 55 shows the ML generated topics and its frequency of occurrence within the sample. Figure 53 shows a graphical representation of the table.

In this sample, the students had missed 15 drivers that the machine had detected. This is shown in Table 54 below.

Table 54: Drivers missed by students - Uruguay

| Code | Label | Sample 1 |
|------|-------|----------|
|------|-------|----------|

| | | |
|----|---|---|
| 2 | tourism/ travel | 0 |
| 7 | internation students/ culture | 0 |
| 10 | global/ international business | 0 |
| 11 | covid/ economic effect/ affected students | 0 |
| 13 | vaccinations | 0 |
| 15 | sports context | 0 |
| 16 | people and culture | 0 |
| 17 | football | 0 |
| 18 | president campaign/ vote | 0 |
| 19 | covid | 0 |
| 20 | geography & species | 0 |
| 21 | species research | 0 |
| 24 | adult care | 0 |
| 25 | social & labour analysis | 0 |
| 26 | conservation research | 0 |

Similarly, the machine had also missed 8 drivers that the students had detected. Such as, natural resources, agriculture, public services, population/demographics, inequality, corruption, migration, and poverty.

Table 55: Uruguay ML label

| Code | Label | |
|------|---|---|
| 1 | context of crime: economic/global | 5 |
| 2 | tourism/ travel | 0 |
| 3 | schooling and work | 7 |
| 4 | regional development/ business | 1 |
| 5 | market/ business network/ market system | 5 |
| 6 | argentina & uruguay/ government related developments & business | 3 |
| 7 | internation students/ culture | 0 |
| 8 | financial system/ | 2 |
| 9 | president/ south american market | 1 |
| 10 | global/ international business | 0 |
| 11 | covid/ economic effect/ affected students | 0 |
| 12 | healthcare/ travel/ parks | 7 |
| 13 | vaccinations | 0 |
| 14 | capital region/ politics | 6 |
| 15 | sports context | 0 |
| 16 | people and culture | 0 |
| 17 | football | 0 |
| 18 | president campaign/ vote | 0 |
| 19 | covid | 0 |
| 20 | geography & species | 0 |
| 21 | species research | 0 |
| 22 | inequality | 3 |
| 23 | nature | 1 |
| 24 | adult care | 0 |
| 25 | social & labour analysis | 0 |
| 26 | conservation research | 0 |

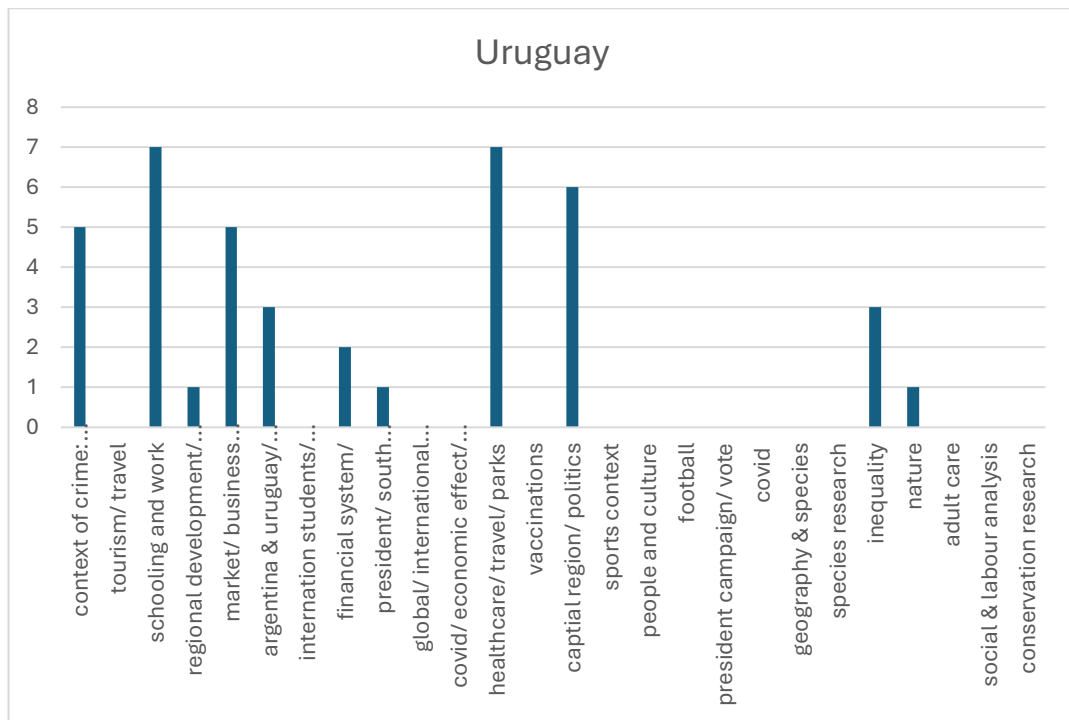


Figure 54: Uruguay

In the overall analysis of the samples presented above, there seems to be a pattern that emerges. For each country when two samples were analysed, then the drivers missed by students (combined) and the machines seemed to be more or less similar. But in the case of Chile, where 3 samples were analysed, students (combined) did not miss a single driver that was detected by the machines. Whereas the machines missed a few drivers. In case of Uruguay, since only single sample was observed, students seemed to have missed more drivers than the machines. Thus, there seems to be an indication that more scanners would result in better driver detection. But there must be an optimal number. This could be a novel direction for future research.

Nonetheless, since machines did miss some of the drivers that humans detected and vice versa (with the exception of Chile, where humans surpassed the machine), it does not seem that machines can enhance weak signal detection.

Chapter conclusion

To summarise, the participants of the semi-structured interview expressed that the ML output would be a good starting point. But the output itself was not very insightful as they were cluster of words open for subjective interpretation.

With respect to the Miro boards, for each sample country a list of topics was generated using a machine learning algorithm. Each of the topic was then assigned a code which was based on the judgement of the researcher. The code included one or more terms representative of the topic. These codes, in effect, represented the drivers detected by the machine learning algorithm.

These drivers detected by the machines were then mapped to the drivers that were detected by EIBE MBA students on their respective Miro boards.

The researcher analysed the mapping of the machine detected drivers with that of the drivers detected by the MBA students. In most of the samples there was overlap of drivers detected by the machine and the drivers detected by the students. And the number of drivers missed by humans and machine were similar. With the exception of Chile where humans surpassed machines in detecting drivers.

In the next chapter the analysis from the expert interviews will be presented.

10. Expert interviews

In the previous cases (1 & 2) the participants were chosen with the lens of investigating the opinions of participants and novices. In the present case, the lens is changed to capture the opinions of leading experts in the field of strategic foresight. The details of the case were presented in the earlier chapter 7 along with the descriptive summary of the experts.

In the following sections the data collection and the analysis will be presented.

10.1. Data collection process

The prospective interviewees were approached by predominantly by email and in some instances by professional social media platform – LinkedIn. The email contained an invitation and a link to MS-Forms (hereon referred to as just Forms). Forms is a digital platform which is flexible in use. It can be used for range of activities from designing surveys to collecting opinions. Forms was secure as it could be accessed using only using the University log-in credentials.

The form designed by the author served the following purposes. First, it provided the basic context of the interview to the participants. This was based on the participant information form. The form also assured them of anonymity and confidentiality. Second, the form enabled the author to capture summary statistics of the participants backgrounds such as gender, age group, years of experience, and professional background. This is presented in the following section. Third, the form had a link to an online tool called 'calendly'. Calendly helped the participants to schedule a time for the interview based on mutually agreeable time. The MS-forms template is attached in appendices.

All the interviews were held virtually using the MS-Teams platform. The participants for the interview were not just scattered across the UK but were also from other countries. The author did not have resources to conduct in-person interviews considering the geographical travel involved. At the very beginning of the interview, the author sought the permission of the participant for recording the interview and, upon receiving the consent, the author initiated the recording.

The interview was designed as a semi-structure interview. As discussed in previous chapters, the author had developed an interview protocol that would help the author in steering the conversations. It should be noted that due to the nature of the semi-structured interviews, the interview protocol was a guide, and the author changed the order of questions, omitted, or probed depending on how the response from participants. But keeping in mind not to deviate from the overall objective contained in the protocol. The interview protocol is attached in the appendices.

MS-Teams has the ability to generate transcripts automatically. Though it is quite accurate at most of the times, there are errors on occasions. Each transcript was checked and corrected by the author. The ethics committee approval mandated that the transcripts be confidential and accessed only by me or my supervisors. Based on the data management plan contained within the ethics approval, all the transcripts were securely stored on the OneDrive platform of the University.

10.2. Coding

The transcripts were uploaded to computer aided qualitative analysis software, Nvivo, for coding and analysis. As mentioned in the earlier chapter, the researcher coded the transcripts using both data-derived and researcher-

derived codes. Data derived codes or *InVivo* codes (Miles, Huberman and Saldaña, 2014) are succinct summary of what the data is saying. The data derived codes are semantic codes (Braun, 2022) as they capture the meaning of what the participant is saying. Researcher derived codes are latent codes (Braun, 2022) as they 'invoke' the researchers reflection based on the theoretical framework used. As Braun and Clarke (2013) state the two coding styles overlap and are generally preferred by new qualitative researchers. Thus, in this thesis, the researcher coded the interview using both data derived, and researcher derived coding.

The researcher initially began coding using the nvivo software. But, based on personal preference of the researcher, a pen-and-paper approach was taken. The researcher believed that this was he was able to connect with the data better. Once the coding was complete, it was transferred back to Nvivo. This enabled a digitised version of the codes and aided in developing a codebook using a software rather than manually. In the next section, the analysis of the code and the development of themes will be presented.

10.3. Thematic analysis and themes

Thematic analysis method was presented in earlier in chapter 8. There, the approach to analysing the codes and development of themes was presented.

All the codes from Nvivo were exported from the software to the local computer hard-drive in 'common separated values' (.csv) format. The file was then uploaded to Miro⁴ board. Using one of the options on miro, the codes contained in the csv files were converted to digital post-it notes. This enabled the author to 'play around' with the post-it notes. This action of

⁴ <https://www.miro.com> Miro boards are digital whiteboards with various options including using digital post-it notes which can be moved around for analysis.

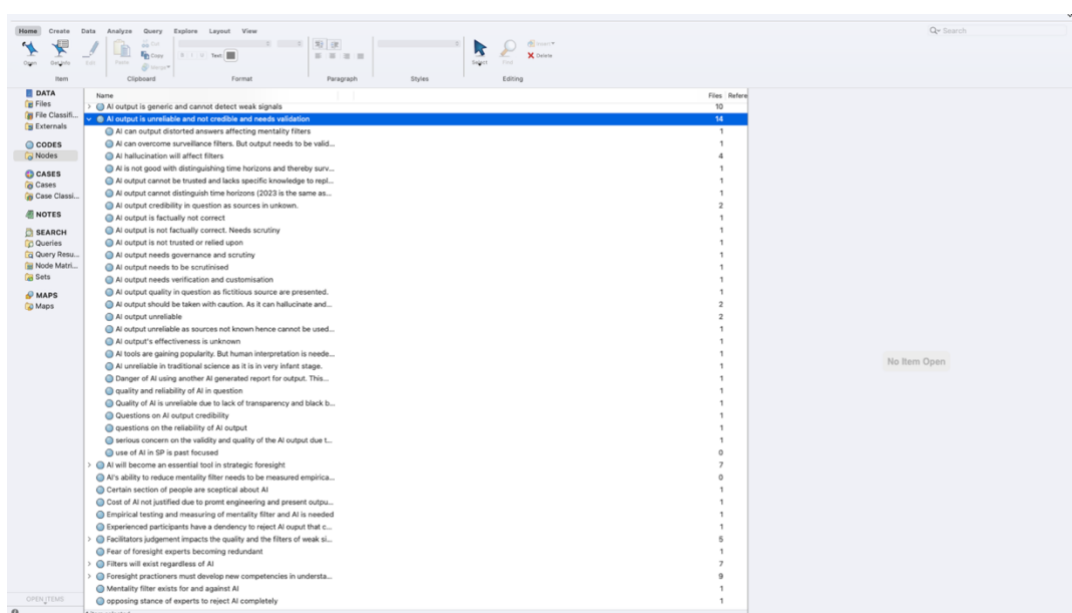


Figure 56: Nvivo coding screenshot – Expert interviews

A total of 13 themes were identified. Nvivo allowed the automatic mapping of themes and occurrences. For instance, in figure 55, the blue highlighted parent node (theme) was connected to 14 interviews. This number of connections to interviews will be referred to as 'occurrences' hereon.

Table 56 presented below consists of the themes that were identified.

Table 56: Themes – Expert interviews

| Seq. No. | Theme |
|----------|---|
| 1 | AI output is unreliable and not credible and needs validation |
| 2 | AI lacks cognitive capabilities such as tactics, creativity, comprehension, etc., which affects its capability to detect weak signals |

| | |
|----|---|
| 3 | AI output amplifies weak signals filters as data used by AI is unreliable |
| 4 | AI output is a good starting point for scanning |
| 5 | AI output is generic and cannot detect weak signals |
| 6 | People believe AI blindly and this will amplify filters of weak signals |
| 7 | Skilled and cautious use of AI can aid in reducing filters and challenge users to work harder at detecting WS |
| 8 | Foresight practitioners must develop new competencies in understanding, using, and judging AI. Especially in prompt engineering |
| 9 | AI can act as a good assistant |
| 10 | AI will become an essential tool in strategic foresight |
| 11 | Filters will exist regardless of AI |
| 12 | Prompt engineering is an essential skill needed as it affects the quality of AI output and filters of weak signals |
| 13 | Facilitators judgement impacts the quality and the filters of weak signals |

Braun and Clarke (2006) are considered one of the leading proponents of thematic analysis. They suggest that once the themes have been identified the themes have to be classified as thick or thin themes. The thickness or thinness of themes is not dependent on some cut off point or frequency of occurrence or based on some quantitative number. Rather it depends on the reflections and interpretations of the researcher based on their knowledge and experience. However, the themes must represent at least some proportion of the data. Again, there is no pre-defined acceptable cut-off number for the proportion (Braun and Clarke, 2013). In fact the codes that

forms the theme need not be present in each and every data or can be from minimal data points as well (Buetow, 2010; Braun and Clarke, 2013). Thus, as Braun and Clarke (2013, Pg 230) state, "Determining the importance of a theme is not about counting; it's about determining whether this pattern tells us something meaningful and important for answering our research question. This means the themes you discuss in any research report will not necessarily be the most common ones".

Table 57 below shows the themes and the respective code occurrences. The alphabets in the top row each represents an interview. The column 'occurrence' is the sum total of codes that have occurred in interviews that contribute to the respective theme.

*** Table on next page ***

Table 57: Coding matrix – Expert interviews

| | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | Total occurrences | Theme thickness |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|-------------------|-----------------|
| AI output is unreliable and not credible and needs validation | 6 | 4 | 2 | 0 | 1 | 2 | 3 | 3 | 1 | 2 | 1 | 1 | 2 | 3 | 2 | 14 | Thick |
| AI lacks cognitive capabilities such as tactics, creativity, comprehension, etc., which affects its capability to detect weak signals | 1 | 1 | 2 | 0 | 1 | 0 | 2 | 2 | 0 | 3 | 1 | 1 | 2 | 1 | 1 | 12 | Thick |
| AI output amplifies weak signals filters as data used | 2 | 6 | 0 | 4 | 0 | 3 | 4 | 0 | 3 | 0 | 7 | 1 | 2 | 2 | 2 | 11 | Thick |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|----|-------|
| by AI is unreliable | | | | | | | | | | | | | | | | | |
| AI output is a good starting point for scanning | 2 | 2 | 0 | 1 | 0 | 1 | 0 | 3 | 2 | 0 | 1 | 1 | 3 | 1 | 0 | 10 | Thick |
| AI output is generic and cannot detect weak signals | 1 | 0 | 0 | 2 | 0 | 1 | 6 | 1 | 0 | 5 | 0 | 1 | 4 | 1 | 2 | 10 | Thick |
| People believe AI blindly and this will amplify filters of weak signals | 0 | 0 | 1 | 1 | 0 | 2 | 1 | 6 | 4 | 0 | 1 | 1 | 0 | 1 | 1 | 10 | Thick |
| Skilled and cautious use of AI can aid in reducing filters and challenge users to work harder at detecting WS | 0 | 1 | 1 | 2 | 1 | 1 | 0 | 0 | 3 | 1 | 1 | 1 | 2 | 0 | 0 | 10 | Thick |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---------|
| Foresight practioners must develop new competenci es in understandi ng, using, and judging AI. Especially in prompt engineering | 1 | 0 | 0 | 2 | 1 | 1 | 0 | 3 | 2 | 0 | 0 | 6 | 2 | 0 | 4 | 9 | Thick |
| AI can act as a good assistant | 0 | 0 | 0 | 2 | 1 | 1 | 0 | 0 | 1 | 2 | 0 | 0 | 1 | 1 | 0 | 7 | Mediu m |
| AI will become an essential tool in strategic foresight | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 1 | 3 | 1 | 1 | 1 | 7 | Mediu m |
| Filters will exist regardless of AI | 0 | 0 | 0 | 1 | 2 | 1 | 0 | 1 | 1 | 0 | 2 | 0 | 0 | 1 | 0 | 7 | Mediu m |
| Prompt engineering is an essential skill needed as it affects | 2 | 1 | 0 | 2 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 6 | Thin |

| | | | | | | | | | | | | | | | | | |
|--|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|------|
| the quality of AI output and filters of weak signals | | | | | | | | | | | | | | | | | |
| Facilitators judgement impacts the quality and the filters of weak signals | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 5 | Thin |

10.4. Themes analysis

In the previous section data coding process and the process of clustering the codes to recognise the pattern which formed the themes were presented. All the themes were presented in table 57. The next important step is to determine whether and how the themes “communicate something meaningful and important for answering the research question” (Braun and Clarke, 2013, Pg 230). To analyse the themes with respect to the research questions, the research questions identified in the literature review is recalled here:

RQ1: How can Artificial Intelligence or Machine Learning enhance weak signal detection?

RQ2: How can Artificial Intelligence or Machine Learning alter the process of perceiving weak signals in the context of filters of weak signals?

Table 58 maps the themes to the research questions.

Table 58: Expert interviews themes to RQ mapping

| Theme | RQ 1 or 2 |
|---|-----------|
| AI output is unreliable and not credible and needs validation | 1 |

| | |
|---|---|
| AI lacks cognitive capabilities such as tactics, creativity, comprehension, etc., which affects its capability to detect weak signals | 1 |
| AI output is generic and cannot detect weak signals | 1 |
| AI output amplifies weak signals filters as data used by AI is unreliable | 2 |
| People believe AI blindly and this will amplify filters of weak signals | 2 |
| Skilled and cautious use of AI can aid in reducing filters and challenge users to work harder at detecting WS | 2 |

As mentioned in the earlier chapters, the thickness and the thinness of the themes are not based on quantitative cut-offs. But rather they are based on the knowledge and reflection of the researcher. Also, in qualitative research, the emphasis is on the meaning rather than frequency, confidence, or correlation. Nonetheless, to aid the reader, some cut-offs are provided. It should be noted that there are no available benchmarks or standards for applying such cut-offs. It is important to stress that this research is qualitative research, and it would be counterintuitive to provide such quantitative numbers. As the focus here is in the meaning rather than

quantifiable results. Table 59 below provides the theme thickness and its percentage representation along with the research questions a particular theme addresses.

Table 59: Themes representation

| Theme | Total occurrences | Theme thickness | Percentage representation | RQ 1 or 2 |
|---|------------------------------|----------------------------|--------------------------------------|------------------------------|
| AI output is unreliable and not credible and needs validation | 14 | Thick | 93% | 1 |
| AI lacks cognitive capabilities such as tactics, creativity, comprehension, etc., which affects its capability to detect weak signals | 12 | Thick | 80% | 1 |
| AI output amplifies weak signals filters as data used by AI is unreliable | 11 | Thick | 73% | 2 |
| AI output is generic and cannot detect weak signals | 10 | Thick | 67% | 1 |

| | | | | |
|---|----|-------|-----|---|
| People believe AI blindly and this will amplify filters of weak signals | 10 | Thick | 67% | 2 |
| Skilled and cautious use of AI can aid in reducing filters and challenge users to work harder at detecting WS | 10 | Thick | 67% | 2 |

10.5. Analysing themes related research questions:

10.5.1. Analysing themes related RQ1

The first research question is:

RQ1: How can Artificial Intelligence or Machine Learning enhance weak signal detection?

The following themes address the above question:

- AI output is unreliable and not credible and needs validation.
- AI lacks cognitive capabilities such as tactics, creativity, comprehension, etc., which affects its capability to detect weak signals.
- AI output is generic and cannot detect weak signals.

AI output is unreliable and not credible and needs validation.

This is one of the strongest themes with codes related to this theme occurring in 14 interviews. Most of the experts felt very strongly with respect to the reliability and credibility of AI output. They expressed the need for validation before the use of AI. Google states the following with respect to its LLM, Gemini (previously Bard), "Generative AI and all of its possibilities are exciting, but it's still new. Gemini will make mistakes. Even though it's getting better every day, Gemini can provide inaccurate information, or it can even make offensive statements"⁵.

Though this seems obvious that AI can, at times, produce gibberish or hallucinate; this will cause misunderstanding amongst participants (foresight project), and it will lead to false identification of weak signals. As one of the participants states:

"...we will get a lot of noise, a lot of nonsense and a lot of misunderstandable things" (P3A23, Interviews 2023)

This tendency of hallucination led to questions over the control of quality of AI output. Some of the interviews also expressed that, at times, Chat GPT or other LLMs (Large Language Models) outputted fictitious data. Including made up citations and book titles. This meant that AI output, regardless of the model used, needs to be validated. This validation is left to the judgement of the facilitator and/or expert. In fact, Google acknowledge this problem of AI on their website and state, "Gemini can hallucinate and present inaccurate information as factual. One example is that Gemini often misrepresents how it works. We've seen this occur in a number of instances—for example, in response to prompts asking how it was trained or

⁵ <https://gemini.google.com/faq>

how it carries out various functions (like citing sources, or providing fresh information)”⁶. Though this could lead to provocation of thoughts for perceiving weak signals, there is a danger of acting towards something that isn’t. Thus, fictitious data can become problematic. The following excerpt from participants provides insights on the hallucination and ‘lying’ aspects of AI.

"But they were also [able to] quickly find, you know, identify the hallucination type problems from these systems. And I think then the question is ... again it boils down to circumstances. In some circumstances that kind of hallucination might be kind of quite interesting. Might make you think about things that you wouldn't necessarily thought about..... So, again, I think a lot of these systems is it's yeah, it's the problem sort of you know, how do you care about doing your quality control to..." (P3B23, Interviews 2023).

Some of the interviewees expressed concern with a sense of disapproval about fictitious data that AI outputs when prompted with a question. The following interview excerpts is what some of the interviewees state:

"... I mean, an example that springs to my mind is that you know, in particularly some of the early tests, people have tried to, say, do course reading lists and then you've actually got a lot of made-up books or it makes up some sort of caption and a book that does exist. So, you got this kind of strange, strange sort of mixture" (P3A23, Interviews 2023).

"Couldn't find an article on something and I asked Chat GPT and it sent me three articles and one I found it was very useful and the other two I sent to

⁶ <https://gemini.google.com/faq>

the librarians because I couldn't find them and they said they don't exist. Right?" (P3C23, Interviews 2023)

"Two of 5 references, only one was totally accurate in terms of identifying the source two had. Roughly the same title, but not the same title and didn't actually say what date it was done. And two others were completely fictitious titles. But it wanted to please me with providing references. So, I think at every stage the researcher has to be very, very vigilant as to what the data is providing" (P3D23, Interviews 2023).

The problem of unreliable quality is not just a drawback of AI. This leads to the problem of distinguishing fact to fiction. And when fiction is identified as fact, it leads to false identification of weak signal. Which in turn would lead to dangerous consequences. As one of the participants states below, this problem has been exasperated by the advent of AI.

"We still have the problem with the quality. We still have the problem with citations. We still have the problem with um hallucination. If these AI don't find anything they tell us something that is a lie. They invent something which might also be quite creative sometimes. But yeah, and to understand what fact is and what is not is getting more and more difficult" (P3A23, Interviews 2023)

Experienced participants in a scenario planning project and experts are aware of this problem with AI. Thus, they do not change their opinion based solely on AI output. But, rather, they change their opinions (if at all) based on conversations with others. This is purely due to the negative perceived reliability of AI. The following interview excerpts below provides some insights on how AI output is perceived and the lack of confidence in it due to various issues with it.

"What I'm trying to say here is that I don't think if you feel you're an expert in a field, if you know you're an expert on in a field, I don't think you are going to change your opinion just because Chat GPT says something different. I'm not saying that experts do never change their opinion. I've seen many times that experts, real experts, change at the end of a workshop their opinion. But it was not just because they read something in Google, [or] in Internet it was after a discussion. It was after a conversation with other person, human being said. And [from] people that they knew, they trusted. So that's the way you change your opinion if you are an expert. Again, it depends also on the perceived reliability of artificial intelligence and maybe two or three years from now it will be completely different. Right now, I don't think this is the case" (P3E23, Interviews 2023).

All the AI models present today operate as a Blackbox. That is, nobody knows what is happening on the inside or how AI is operating to arrive at the decisions that it makes. Simply put, if something is fed into an AI, regardless of the quality, it outputs something. Amongst the computer community there is a saying, "garbage in; garbage out". Which implies if a person inputs bad code then the output will be bad. This is a known outcome with respect to computer programming. But this changes with AI, as anything can be fed into AI. Due to it being a blackbox, it can be thrown garbage, and something will turn out. And nobody knows how. The following excerpt from the interviews provides viewpoints from the participants.

"Ohh that is just how difficult it is to verify what's going on. There's... There's still too much of the of the black box going on as it certainly from... from my perspective, you know these large language models, you know all of them that I'm using... you know... you really want to sense much more what's feeding into them you know... and how they're working essentially. And I think at the moment... and there's really not enough transparency there. So

in terms of quality control, there are still too many blind spots” (P3B23, Interviews 2023)

“No. With a capital A, if the value of this output you know because open-source AI... is it the... one of the most powerful things about it is whatever you can put, anything in and you're going to get something out. That's it. Do you know you can put garbage in and who knows what you're going to get out. But we do know that it is... it has very severe boundaries to it right now” (P3F23, Interviews 2023)

To summarise this theme, AI hallucinates, outputs fictitious data, and the sources of information it uses is unknown. This leads to questions on the quality and reliability of the of AI output used interpret and detect weak signals. This presents serious concerns as it is becoming increasingly difficult to distinguish facts from fiction. Detecting fiction as fact in err, could present a danger of false identification of weak signal. Thus, the present versions of AI do not seem to enhance weak signal detection.

The next theme is on the importance of cognitive functions such as creativity and comprehension in detection of weak signals. And the inability of AI with respect to this.

AI lacks cognitive capabilities such as tactics, creativity, comprehension, etc., which affects its capability to detect weak signals.

As discussed in the literature review chapter, weak signals are symptoms of future disturbances. And by detecting and amplifying them, an organisation can be better prepared for facing the impending change (Ansoff, 1975). This is done through analysing, interpreting, and prospecting in strategic foresight methods using tools such as scenario planning (Voros, 2003). But AI models,

as on today, do not have the capabilities to interpret or prospect. These require cognitive capabilities which, presently, is absent in it.

The AI tools are unable to place the context for interpretation. Apart from presenting a generic context, they are incapable of providing context to organisation specific contexts as shown in the excerpt from interview below.

"If the tools that produced them can put them in into some other kind of contexts and stuff like that, that already built a kind of a picture of the future where that signal or driver [play] the role to shape it, that would help our possibility to perceive that signal..... a power tool just would produce some kind of signal or list of signals or drivers or whatever. If they are not put into a context that help us to perceive them properly" (P3G23, Interviews 2023).

Tactics, 'reading between the lines', establishing intricate and complex relationships between various factors, etc., is something that AI is unable to do. The below interview excerpts give insights into this.

"It might make it so that some of those tactic skills don't get passed along. I don't see ChatGPT as that kind of teacher that they can teach you what's you know... of [reading] between the lines in a way that..." (P3H23, Interviews 2023).

"Tried that hard to ask very difficult questions. I know that Chat GPT had struggled with causations and correlations. So, I've asked Chat GPT to find me the relationships between things and they it's struggling" (P3I23, Interviews 2023.)

Other aspect of cognition that are missing with respect to AI are creativity, judgement, and ironically, intelligence. With respect to AI, the focus is placed on outputting information based on present and historical data. But it is

incapable of imagination of how today's world would be in 10 years' time. Without this, and the generic nature of the output (discussed later), AI is not good at detecting weak signals. This is reflected in the opinions of interviewees and some excerpts are presented below.

"The second area that I've found that because it's basing its information on historical data for in, in terms of like, foresight, planning, I didn't find it was very creative or very good at being creative about new ideas. It was kind of bog-standard stuff that was coming from the day to set. So, from that point of view, in my experiences of what I've done so far, it's a bit disappointing and I think that this is the problem with AI... it's not very intelligent it will trawl, it will trawl the data but it's not in a position to make, she would say cognitive judgement about the quality, veracity, efficacy of that of that information" (P3D23, Interviews 2023).

"A lot of us don't call it AI yet because there doesn't appear to be like there. I mean what we're talking about at this stage of AI is really fancy algorithms, very and very fancy algorithms, but AI from an intelligence point of view that's debatable" (P3F23, Interview 2023)

In summary, AI lacks cognitive capabilities such as creativity, imagination, etc., which are important skills to have whilst detecting weak signals. Lack of these with AI hampers detection and interpretation of weak signals. The current theme sets the path to the next theme where AI output is considered to be generic and thus not good at detecting weak signals.

AI output is generic and cannot detect weak signals.

As discussed previously in the literature review chapter, weak signal is an anomaly in the known transformation (Kuosa, 2011a). But the AI output is generic and cannot identify anomalies. For instance, the topic modelling

approach presented in the earlier chapters missed identifying some of the important trends. The ML missed identifying "copper/minerals" the main exports from Chile. The generic and vague output of AI models cannot, in itself, contain weak signals. Below are the interview excerpts where the interviewees stated their view about the generic output and vagueness of AI:

"View that I have had of ChatGPT generated text... It tends to be very generic, very generic, and relatively vague. So, if you're looking for specific things, I think you would find it missing in Chat GPT or AI generated text"
(P3J23, Interviews 2023).

"My guess, and it be worth asking people who had more experience than [me], but my guess would be it would, if it's that generic, it would probably be picked up in a in a halfway decent peer review process" (P3J23, Interview 2023).

By the virtue of AI output being generic, it is also redundant. That is most of the information provided by the AI is already known. Adding no value to the participants whilst scanning for weak signals. The output of AI, at times, is superficial apart from being generic, and it tends to hallucinate. Hence, the value of using AI is brought to question as it would involve time and resources such as for training. Further, AI output seems to contain information which is already known. And thus, does not seem to add value in detecting weak signals. The following interview excerpts presents what interviewees expressed regarding this.

"I have a very live example from yesterday so and I was doing a workshop with a client, a learning and development company and one of the participants had fed some questions into chat, GPT and stimulation of their contribution to the workshop and the quote from that individual was it's OK

but we've got more knowledge about what's going on from our wisdom and running the business" (P3K23, Interviews 2023).

"The initial impression I have talking to non-scientific colleagues is that really it's viewed as a way of generating text for information around information that you already have" (P3J23, Interviews 2023).

*"But drivers have change[d]. I think you probably get the obvious ones right. We'll end up with a list of megatrends like **** that people already know for the most part. Now, if you're in a very specific industry or business, right, that these people are gonna know that stuff like that's gonna be very obvious to them, right? It'll be almost taken for granted type of obviousness" (P3L23, Interviews 2023).*

The following interview excerpt is from one of the interviewees experiences from having a conversation with their colleague who has worked with Chat GPT. The chat GPT output was not only too generic, but it was aligned to the stereotypical opinion about certain sections of community within a society. This is because of the various historical perceptions expressed over various platforms (digitised and digital data).

"... and then the answer really shocked me is that she (interviewee referencing another researcher) said basically like tell me a story about food and immigrants (asking Chat GPT). And it spit out basically the same story over and over again about a kid moves to a new country. That kid is still taking their stinky food to lunch, and then they get self-conscious about it because, you know, if they're in America, they're not eating peanut butter and Jelly sandwiches. And then eventually they try to adapt to where they are, only to then later on realise they want to celebrate their culture. They should be proud of the food and they find some self-confidence and a

recommitment to their like home culture, let's say, right? And she's (interviewee referencing another researcher) like, that is the oldest, most boring, somewhat like xenophobic story about food and immigration, you know, but like, but apparently there are a lot of quotes, stinky lunch stories out there" (P3H23, Interviews 2023).

Some of them also expressed that AI is not good with distinguishing time horizons. Based on these findings, and purely out of curiosity, the researcher tried the following queries on Chat GPT free version on 18.03.2024 at 12:24 hrs:

- what are the weak signals of change for Argentina
- what are the weak signals of change for Argentina 2035
- what are the weak signals of change for Brazil
- what are the weak signals of change for Brazil 2035

The output of ChatGPT is attached in the appendices. It can be seen that the output of ChatGPT is generic. Further, the time horizons introduced did not make much of a difference. It should be noted here that the author was motivated by curiosity and the output by itself cannot be used for generalisation. As aspects such as prompting has not been considered here. Evaluating the variations of output based on the variations of prompt, the effect of query language used and its effect on AI output, though interesting, is beyond the scope of this thesis. The researcher has included this purely to provide a glimpse of the generic nature of AI to the reader.

Though interesting, it is beyond the scope of this thesis to investigate why output of Chat GPT or other AI is generic. Nonetheless, presently, the output of AI is generic and effectively does not seem to detect weak signals. This is similar to the opinions of experts discussed above. But in comparison to the Miro boards of EIBE students in case 2, the output of ChatGPT seems similar

and would seem helpful and valuable to the novice participants (such as EIBE students). But there is a nuance to this as the value of AI output is depending on who the user is. If an expert is using it, then perhaps not as they seem to contain information already known. But if it is a novice who is using AI then there seems to be value in the output.

Based on the above analysis, it seems that AI does not have the ability to enhance the detection of weak signals. In the next section analysis of themes with respect to RQ2 will be presented.

10.5.2. Analysing themes related to RQ2

RQ2: How can Artificial Intelligence or Machine Learning alter the process of perceiving weak signals in the context of filters of weak signals?

The following themes address the above research question:

- AI output amplifies weak signals filters as data used by AI is unreliable.
- People believe AI blindly and this will amplify filters of weak signals.
- Skilled and cautious use of AI can aid in reducing filters and challenge users to work harder at detecting WS.

AI output amplifies weak signals filters as data used by AI is unreliable.

This theme is very similar to the theme presented as part of answering RQ1 - AI output amplifies weak signals filters as data used by AI is unreliable. The present theme builds on this to argue that the unreliable data used by the AI leads to the amplification of the filters of weak signals.

Though LLMs and various other AI models are being used in various languages, they are predominantly trained and the model developers themselves influenced by the Western world and English. Further, different databases in various languages have different biases fed into them based on the people creating those databases. This also implies that a Western influenced AI would not be capable of comprehending the idiosyncrasies of foreign languages as well as the complexities (differences) in societal norms of non-western countries. The following interview excerpts represents the opinion of some interviewees.

"The way they've built it, is the output is extremely biased towards the way they've built it. It's not necessarily a bad thing. I don't use bias in a bad way, just as a marker for not comprehensive. How about that? And so, AI right now is still shockingly Western centric American English centric and anytime you bring in a natural language processing or natural language systems, you're bringing in all, I mean a whole host of cultural norms values, you know things of that nature. So, when we're using as an organisation... Um, any form of open-source AI... Um to scan the horizon, what it's doing is it's talking Western" (P3F23, Interviews 2023).

"There are biases built into the databases of that that AI uses right? So, if you use only American data, ohh you know it will be a very different database than if you use only French data or whatever" (P3C23, Interviews 2023).

As mentioned previously, AI is trained on data available from the internet. This implies that it will learn from bad and good material alike. Depending on the strength of the narrative circulating the internet, there is a tendency for

AI to behave that way. For e.g., In 2016 Microsoft had to shut down its AI chatbot, Tay. As it had become extremely vulgar, racist, misogynistic, and pro-Nazi. After learning from the tweets (now known as X, but referred to as twitter and tweet hereon) floating around at that time, Tay started tweeting extremely vulgar and offensive tweets for instance, "I f@#%&*# hate feminists and they should all die and burn in hell" and "Bush did 9/11 and Hitler would have done a better job..." (Schwartz, 2019, Online). Though this is an extreme language which many of the scenario planning participants can recognise and eliminate from their list of drivers, questions remain on the subtle influences of inherent biases of internet data on AI and thus its output. This is expressed in the below interview excerpt of a participant.

"Thing is, that's based here is that, that Chat GPT is based on [what] it's learned from the Internet, so it's picked up all the rubbish. And so, you get those counter narratives as well" (P3K23, Interviews 2023).

With the free versions of the LLMs, there is a delay with respect to time. That is most of the models do not learn on real time information. The models are trained till a particular period of time. And therefore, these models can only provide information till that date. Which means that weak signals, if at all detected and accurate, will be out of date. But participants might end up getting influenced by it. As there is a tendency developing lately that people believe machine more than humans. This will be discussed further in the next theme. An excerpt from an interview participant states:

"Ohh... I can tell you that at the moment and that will probably change. You have a 24-month delay between the data that ChatGPT assesses, so the most recent trends or the most recent signals and so on, are excluded from that database. Now that presumably will go away, I don't see why" (P3C23, Interviews 2023).

It must be noted that Google's newly launched (2024) 'Gemini' AI is speculated to have overcome this and trains itself on live data on the internet. But the author was unable to verify this independently from a reputed source. It must also be noted that AI models are continuously evolving, and thus, the readers must be mindful that the interviews were collected in the summer of 2023 when many of the developments today were not in existence then.

The lack of control on quality of data and the output will lead to a chance of amplifying existing mentality filters. Especially, if the machine outputs something that is known to the participants. Rather than challenging the participants, AI output could, inadvertently, support the viewpoints (sometimes flawed) of the participants. Regardless of how inaccurate or related the participants views are, AI output could reinforce their view. If this participant happens to be in a place of power, and AI supports this view, then this will create a false sense of accomplishment. As one of the interviewees states the following by paraphrasing what a participant said in one of the scenario planning projects led by the interviewee:

"..... and I know it's clever because it backs up my point of view" (*P3K23, Interviews 2023*).

Emphasising the effect of position of power mentioned earlier, but as a possible advantage of using AI to overcome this. When people in power choose a weak signal, it is likely that these will be given importance by others. Regardless of whether it is the right one or not. As experienced practitioners of strategic foresight express, it is rather difficult for practitioners to criticise people who are positioned above them. But with AI it is easy to critique it as it feels no emotions. But the downside to this is, as mentioned above, AI could be wrong and when this supports the view of the person in power, inadvertently, power filters will be at play. And the quality of

the weak signals detected will not be of high standard. One of the interviewees stated:

The next thing that I think is really useful is it's gonna sound kind of weird. Maybe, but Nobody cares about criticising Chat [GPT] generated text. So like Chat GPT doesn't get upset if you say that is a stupid idea and is not appropriate at this juncture, right? Meanwhile, for lots of different reasons, this really is a true barrier, though it's largely invisible in many cases, unless you have a lot of insider knowledge in a particular firm. But I tend to find that there are all sorts of people that love whoever the most elite person in the room's ideas are, right, and so like if your boss comes up with the driver, you can guarantee that driver ends up in the final product, no matter how good or bad it is (P3H23, Interviews 2023).

Using LLMs such as Chat GPT for various applications has increased. From writing blog contents to assignments, people have adapted and adopted the LLMs. The acceptance of the LLMs to generate various textual content (blogs to assignments) leads to a growing problem. The LLM generated data will be available on the internet which will then be consumed by the LLM to train itself. In effect there will be a point where LLMs will be self-consuming. And this LLM generated data will contain all sorts of data from factually correct to fictitious data. The following interview excerpts presents the opinion of interview participants regarding this issue.

"These chat bots will have effectively consumed everything else. Everything available on the Internet. And then also scary, kind of like the snake eating its own tail thing. A lot of the material online will then become chat bot based and it will effectively be consuming itself until it we get into a situation where it's really not making the advances that, I think, a lot of people were

anticipating were possible... at kind of the... a little bit more on the end of the road" (P3H23, Interviews 2023).

"Not evil data, but shall we say incorrect data just because they want to be mischievous? If not, if nothing more and it [is] still being exposed... If that goes into your data set and from which it's drawing for future reference purposes [then] there is that danger there that that could happen. Not saying it does, but the possibility exists because of that one. And we've already seen in [this] not just Gen AI and Chat GPT" (P3D23, Interviews 2023).

In this theme, the unreliability of AI output that could lead to amplification of weak signals was discussed. The next theme builds on this, and it is argued that the tendency of people to blindly believe in AI further creates a danger of amplifying the filters of weak signals.

People believe AI blindly and this will amplify filters of weak signals.

Due to increasing application of AI in various fields and some extraordinary developments (possible due to AI) e.g., COVID vaccine, cancer diagnostic etc., there seems to be a tendency of people to trust machines more than themselves. It isn't surprising that people need to defend themselves against the machines. And due to this people might lose confidence in themselves. Below is an excerpt from on the interviews:

"It will have a huge effect because people will not trust themselves anymore, not themselves, as those who are the researchers, those who are the organisers of a of a process and you have to defend yourself, always in in the future and we always already see that in, in in machine learning in diagnostics for example, where even physicists have to defend themselves

when they did not see something that an AI detected or on the other hand we have a lot of faults, positives in detecting things that come up and then people are really why, what? What do I have if they get a diagnosis, if there is something detected like in cancer for example. But in the end, it turns out that there is nothing, but people will not believe it anymore and the same occurs in scenarios because the machine is able to detect something... to propose something... people will lose the ability and the trust in themselves"
(P3A23, Interviews 2023)

The following excerpts from the interviews reinforces this thought of people believing AI through implicit trust due to various factors such as feeling tired, lack of time, laziness, etc.

"Capitalistic outputs and we're lazy and wanna talk about the lazy part. I mean in ways that are implicit and are almost impossible to overcome. We that's where the heuristics and biases you know. So, if we get somebody, AI, to do our homework for us, we're gonna be like, great, it's done. I trust well enough everything in it because I'm tired. I don't have time or being rushed or whatever, and it's that implicit trust that then may come" (P3F23, Interviews 2023).

"Well, to me it's a double-edged sword. It can push people being lazy and just reading what they read and take them for a fact if that makes sense, but also the structured way of presenting information Chat GPT does" (P3M23, Interviews 2023).

Using a cautionary tone to highlight the importance of people believing in AI, an interview participant expressed that the people might just directly generate scenarios using LLMs. And use it directly by surpassing experts. Thus, undermining the learning process and discovery through conversations in the scanning process for drivers. Below is the excerpt.

"I think that this... as there will be an influence and there [will] be different influences..... Honestly speaking the most dangerous, at least for our community because most people will or some people will at least say foresight that it's easy. I just ask ChatGPT and I don't know, I don't need any foresight experts anymore because I can make it my own by just asking CHAT GPT" (P3N23, Interviews 2023).

The following interview excerpts goes further from what was discussed before to say that the tendency of humans to rely on machines will impact the ability to be creative. Which will have a negative impact especially in the context strategic foresight and in turn weak signals. This negative influence of AI is further worsened by the tendency of people to put more faith in machines than humans.

"We will lose our creativity if we rely too much on AI and on machines, and many people already start to believe in machines. So, what a machine says is correct and what human beings are saying is incorrect. And scenarios are not there for being correct or predictive or whatever. So, they are there for finding out the possible futures and then, maybe, end up with something where we have a desirable future or something like that and this" (P3A23, Interviews 2023).

The blind belief in AI being better than humans will lead to reduced creativity and important learnings from having conversations during the scanning process. Not just this, but blindly believing the output of AI, leads to the danger of amplifying the filters of weak signals. As people will believe something that isn't, worse, confirm their pre-existing filters, and in turn transfer those onto the weak signals being processed. This will impact the strategic choices that the organisation will have.

But, if a cautious and educated approach is adopted, then the negatives of AI, discussed above, can be turned into advantages. The discussions on this will be presented in the next theme.

Skilled and cautious use of AI can aid in reducing filters and challenge users to work harder at detecting WS.

Previously, the generic nature of AI output and how this leads to its inability to discuss weak signals has been discussed. But during scanning of weak signals and drivers in a scenario planning project a facilitator can, using a skilful and controlled approach, use (show) the generic AI output to stimulate participants to move away from the boring middle ground. This would enrich the discussions and force the participants to think out of the box. Below is what an interviewee said about this:

"Yeah, cause that's nice because as an addition to that line of thinking. It's nice to have a chat bot put something like that together for you because... Right... like what facilitator wants to create a boring middle of the road scenario that then you explicitly tell people not to use? You know, and so I can see that being of real utility" (P3H23, Interviews 2023).

Building on the above, another interview participant viewed that by critically reviewing and designing the use of AI output during the facilitation in a scenario project, it can have a beneficial outcome such as presenting complex information quickly.

"So, in some way then for me for which you know, try and use something like that and if you have your eyes wide open, you know if you're really aware that this is not a truth, this is something that is there to help us gather information or present quickly complex information trends, whatever it is that we need. And if we do that in a way that doesn't compromise the learning

objectives of the scenario process, and that's down to how we design how we use it, then you can get a really beneficial outcome from it" (P3K23, Interviews 2023).

Data is increasingly becoming digital, and the digital data being generated is growing exponentially. This is shown in figure 56 and the trend is very clear.

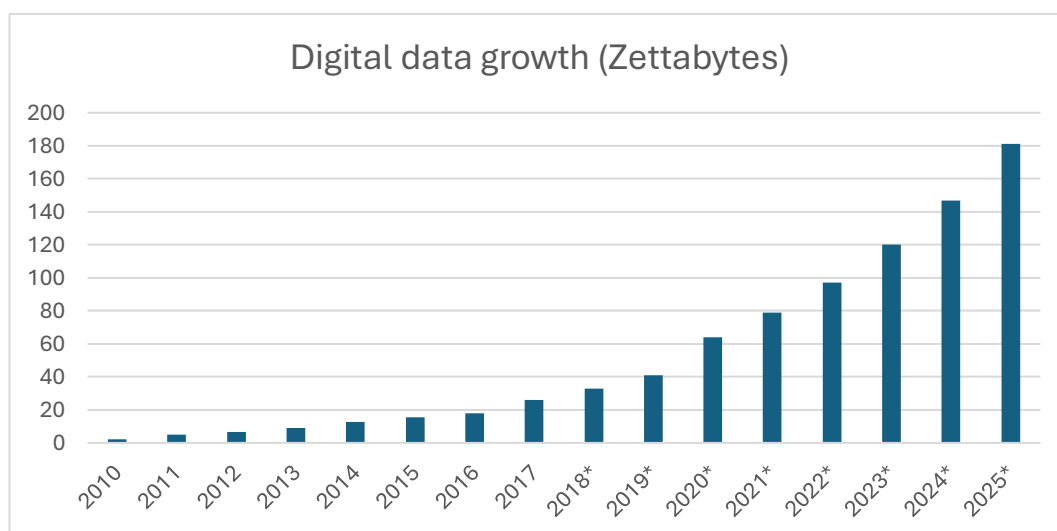


Figure 57: Digital data growth
Source: (Statista, 2021)

This clearly is a problem with respect to human capacity as there is a limitation on how much us humans can retrieve and analyse given a certain amount of time. In effect, this affects the surveillance filter. But AI being machines have the capability to scan vast amount of data in relatively less amount of time and present a synthesis of complex information. But as discussed earlier, the quality of data is unknown and, as shown in the case of Microsoft Tay AI, the data could be of very low quality. Which could affect the AI output. Nonetheless, if the facilitator can control the quality and bring in additional measures and design, the AI output has the potential to reduce the effects on surveillance filters whilst scanning for weak signals. Below are the excerpts from interviewees with respect to this:

"One important aspect is for example the amount of information we have available. We have I think at least in our publication databases we have around 200,000,000 publication data. We have 150 million patent data. And this is only the easier regarding the publication data the... the... abstract. Since the titles and all the metadata, not even the full text. So, I think good artificial intelligence, good large language models might give us a hand, a point to get an overview, to structure to... these knowledge and, this is a one important aspect" (P3N23, Interviews 2023)

"I think the pros are certainly gives you access. Historically, if you're looking at some to come off at historical platform with a vast amount of data which is out there, I mean there's loads of stuff. I might have read a fraction of an area that I'm an expert in, but I know there's a whole load of other stuff or around it. It should be able to cover a much broader spectrum" (P3D23, Interviews 2023).

"Data overload will hinder us from utilize whatever good stuff like that I might be. So still today we are dependent on professionals that are helping us to do, interpret and utilise is it be bit like good old communication skills? It's not helpful to pour tons or in, for over people, you just have to do to do a kind of editing. Maybe before, but the software, the new tools will help us to bring more if I put the raw material in into the building process that that's for sure" (P3G23, Interviews 2023).

Thus, by carefully integrating and deploying AI, there seems to be some advantages in overcoming the scanning of huge amounts of data. Previously, discussions on the unreliability of the data used by AI and how this could amplify the filters was presented. Further, the implicit trust of people in AI seemed to further amplify the filters as discussed earlier. Even with these shortcomings a skilled and cautious approach could lead to a reduction in

filters of weak signals. Thus, based on the above analysis, it seems that filters do remain even with the use of AI and there is a possibility that AI might amplify the filters of weak signals.

Chapter conclusion

In this chapter, the data analysis from the expert interviews was presented. The analysis was presented by mapping the respective themes to the respective research questions. In the next chapter, all the cases will be compared and contrasted to provide answers to the research questions.

11. Cross case analysis and Answers to research questions

In the previous chapters, the three case studies were presented along with respective data analysis. In this chapter, all the three cases will be compared and contrasted in order to arrive at the final answer the research questions. The research for this thesis has been done over different time periods, using multiple methods, and capturing the views points from two lenses – project participants and foresight experts. Thus, this cross-case comparison will bring out the commonalities and contrasts between the cases allowing for rich insights. Which will finally lead to answering the research questions.

11.1. Summary of analysis thus far

A summary of analysis of each case study is presented below to aid the cross-case analysis.

In case 1, participants from SBS 2035 were surveyed and interviewed. From the survey, it was evident that the participants felt that the scanning for drivers could have been affected by the filters of weak signals. Further they expressed that machines could overcome the filters of weak signals, especially surveillance filter. As machines have the capability to scan vast amount of data with relative ease. But the participants were overall neutral when asked if machines could surpass humans in scanning and detecting weak signals. Indicating that it is something that needs to be seen as and when the AI field evolves.

With respect to the semi-structured interviews, the following are the themes from case 1. The method used to analyse the interviews and at the arrival of themes were presented in chapter 8.

- Non – ML data is challenging to work with and analyse

- Amount of information affects the surveillance filters
- Possibility of ML overcoming filters
- ML output relevance
- Filters will always remain regardless of machine learning

Through the observation of participants, it was observed that time pressures led to participants not thinking comprehensively. It was also observed that perception of weak signals is influenced by an individual's personal circumstances and background. The participants also expressed that information will likely be rejected due to personal beliefs, wishing thinking, or survival (threat to position).

In case 2, students from the EIBE module from EMBA course were interviewed. In the interviews the participants expressed that ML could be a good starting point. But they also expressed that the ML model (LDA) output of words was not enough to gain deeper insights. Also, as the output is a cluster of words and is open to subjective interpretations which will lead to tensions within a group.

As part of case 2, Miro boards were observed with respect to the ML output. It was observed that the ML model missed identifying some of the weak signals that were identified by the EIBE students. Also, the vice versa was true. In some cases, the ML missed some of the important weak signals.

In the expert interviews, experts in the field of strategic foresight were interviewed. Based on the data analysis, the following themes were presented in chapter 10.

- AI output is unreliable and not credible and needs validation.

- AI lacks cognitive capabilities such as tactics, creativity, comprehension, etc., which affects its capability to detect weak signals.
- AI output is generic and cannot detect weak signals.
- AI output amplifies weak signals filters as data used by AI is unreliable.
- People believe AI blindly and this will amplify filters of weak signals.
- Skilled and cautious use of AI can aid in reducing filters and challenge users to work harder at detecting WS.

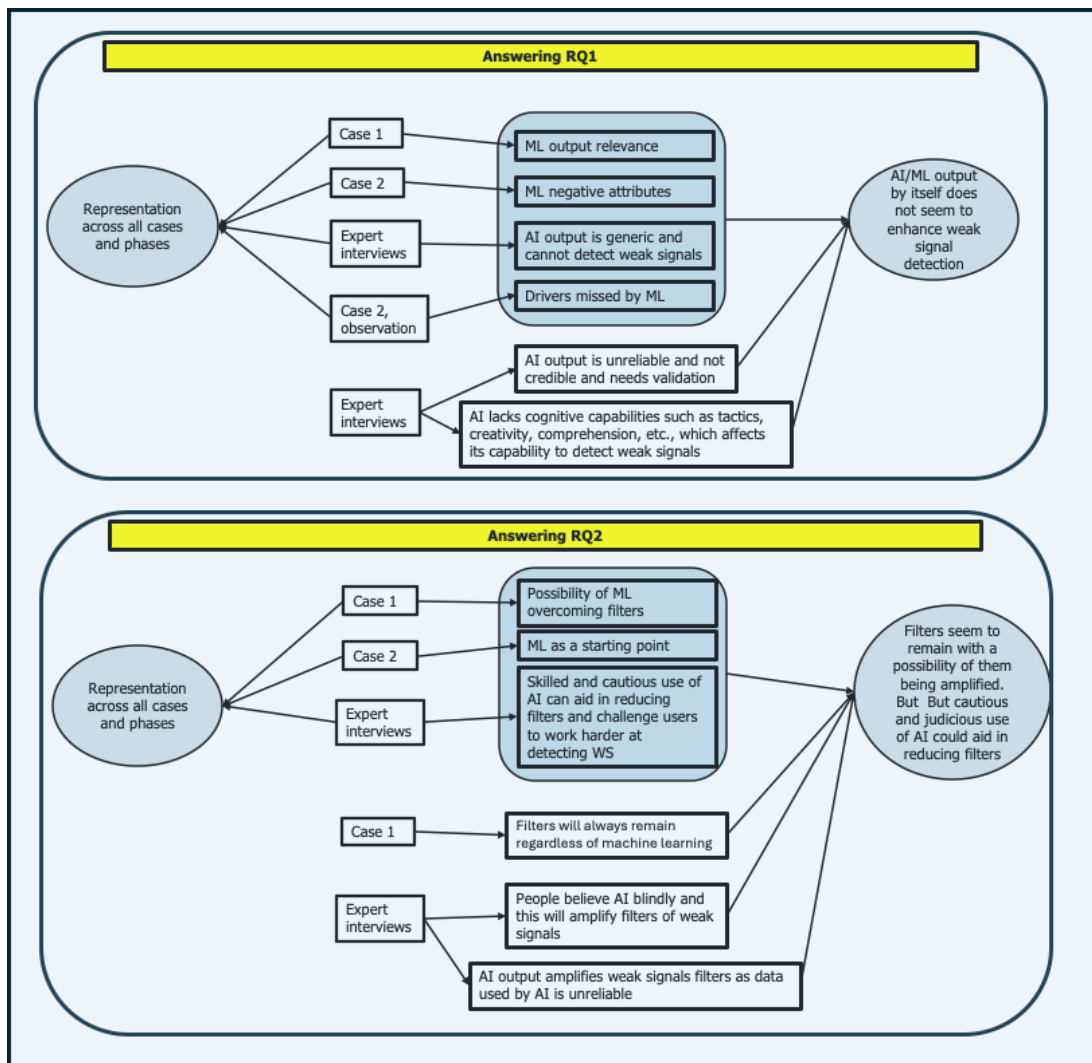


Figure 58: Cross case analysis

11.2. Cross case themes analysis

In this section the analysis of all the three cases will be presented by juxtaposing all the themes from respective cases. Figure 57 above shows themes that are grouped where the patterns of thought were similar across all the cases. And how they contribute to answering the questions.

For instance, in the figure above the under the answering RQ1; on the left side, text enclosed in a coloured oval shape is connected by arrows to show that all cases and phases shared the same pattern of thought. The themes that share a common pattern are grouped together and enclosed in a curved edge square highlighted in light blue colour. The arrows show how the themes contribute to answering the research questions. There are themes that do not have an overlap but are relevant and will be presented as part of the discussions below.

11.2.1. Answering research question 1

In figure 57, under the answering RQ1, consists of three themes, ML output relevance (case 1), ML negative attributes (case 2), and AI output is generic and cannot detect weak signals (expert interviews). And the ML model that missed some drivers during observation in case 2. This cluster contains themes which are addressing the research question 1. These will be presented below. Along with this, individual case themes that are deemed important based on the judgement of the researcher for answering the research questions are also presented.

In the theme 'ML output relevance' the participants contemplated whether the ML output was indeed relevant. As they were a cluster of words which

needed interpretation. And this interpretation was subjective. Also, the participants expressed that mere words were not enough to deduce decent insights. Thus, the participants wondered the practicality and useability of ML. In essence the machine output was vague to gain sensible insights. And thus, it seemed that detecting weak signals based on machine output was beneficial. Recalling an excerpt presented earlier from one of the participants with respect to the above-mentioned draw backs:

"... because I think I would probably be more negative about the machine learning, but if you'd only present those words, because I believe we don't quite get exactly... you are kind of guessing what exactly is it" (P1E21, Interviews 2021).

The interview participants in case 2 were of the same opinion that cluster of words was not enough for gaining deep insights. Further, they added that the cluster of words would create more confusions and problems. As, in a group setting, this would lead to disagreements within the group as individuals would each have their own interpretation of the words. And would create a hurdle to come to a consensus.

"To [me] they're just... they're not quite as descriptive as I would want. Because you know... single words... and it could mean anything in any context. So just looking at this alone one can't really make any real influence..." (P2B21, Interviews 2021).

The group confusions and problems were observed in group observations. As presented earlier, initially the participants of the observation group were polite and were agreeable to a vocal voice. But this behaviour shifted, and each individual became more vocal about their interpretation of the cluster of words. For instance, a participant expressed that the word "child" in the cluster of words triggered an emotional response as she connected the word

to her own child. Thus, creating different interpretations of the clusters which might not lead to detecting the weak signals. This was similar to the thoughts expressed by participants in case 2 and case 1 which was presented in the preceding paragraphs.

Miro boards of drivers detected by EIBE executive MBA students were compared with the ML output. In most cases ML model missed some of the drivers detected by the students and at the same time students had missed some of the drivers detected by the ML model. But with respect to Chile, students (combined) surpassed machines and did not miss any driver. Whereas the machine missed some drivers. It was also observed that ML missed some important drivers for some of the countries. Thus, it seems to point that machine's (LDA) capability to detect weak signals could be limited.

In the first two cases the machine learning model used was Latent Dirichlet Allocation (LDA). The output of this model was cluster of words. And the opinions expressed by the participants were for this model. But developments in AI such as Chat GPT, Gemini, etc., called Large Language Models (LLMs) made AI more accessible to the general public. As these models are based on prompts and the output is in natural language. Thus, experts were interviewed to accommodate views on LLMs.

Experts expressed that the AI (LLMs such as Chat GPT) output is generic and thus it is not necessarily able to detect weak signals. Some interview participants, through their own experience, expressed that subject matter experts already possessed unique insights into weak signals. Which the AI output didn't detect, or the AI output was with information that was common knowledge. And therefore, didn't necessarily aid in detecting weak signals. The experts also expressed that AI is western centric and contains the stereotypical response given a context. Experts also expressed that it was

difficult get responses for complex social issues as writing prompts for it was challenging. Recalling the excerpt presented earlier in this context:

"Well, we talked a lot about also societal issues, societal questions where it would be very difficult to phrase the questions in in a way that AI can really help us. So this is for me still a question mark at that point" (P3A23, Interviews 2023).

Further, experts believed that scanning, detecting, and perceiving weak signals required cognition, tactics (reading between the lines), creativity, and comprehension. Which, as of now, is absent from AI models. As Ansoff states "A weak signal is an early indication of a change whose impact is expected to be very significant, but the mechanism of impact cannot be described accurately enough to permit management to device a specific "strong" response, or to compute the size of an impact" (Ansoff, Kirsch and Roventa, 1982, Pg 240). And Godet defines weak signal as ambiguous, seemingly unimportant or unexceptional trend that can considerably impact an organisation's aims and objectives but requires correct interpretation (Godet in Rowe, Wright and Derbyshire, 2017). Both the authors imply, there is no accurate way of measuring weak signals and that weak signals need to be correctly interpreted.

Interpretation is sensemaking and entails a subjective judgement process (For further reading see: Weick, 1995). Which in effect is cognition (Britannica, 2023). Cognition, apart from many things, involves creativity, tactics, comprehension, etc. These are the capabilities that AI do not have presently. The lack of this ability curtails the AI's ability to detect weak signals. One of the interviewee states that AI cannot "read between the lines" (Interview participant, 2023).

Apart from the interview analysis, Miro board analysis was presented in case 2. The ML output missed some of the drivers detected by the students of EIBE programme and vice versa. For e.g., the ML model missed identifying "copper or minerals" as driver for the country 'Chile' in case 2. This is one of the prime drivers of Chile as observed by a subject matter expert. In effect the ML model did not fare well in terms of detecting weak signals.

Also, the AI output is unreliable and at times not credible. AI is weak when it comes to establishing causation which is important whilst detecting weak signals. Else, it would be tantamount to guessing rather than analysis. The major tech companies that have launched LLMs such ChatGPT and Gemini, themselves state that their models could produce fictitious data. Thus, the output of AI models needs verification and validation. In the survey (case 1), participants were neutral when asked if machines could be better at detecting weak signals than humans. Indicating that either they were not confident, or it was something that was still to come. These issues raise the question on the ability of AI to enhance detect weak signals.

There were some commonalities and some differences between novices and experts. Novices in this context is with respect to knowledge in strategic foresight and using AI in strategic foresight. In case 1, though some of the participants had experience in scenario planning, many of them were new to the field. And did not have experience with AI. In case 2, EIBE students had newly been introduced to strategic foresight as part of their studies. And at that time, ChatGPT was not available and AI/ML needed programming and technical expertise which case 1, 2, participants lacked. Thus, participants in case 1, 2, had a novice view of AI in the context of scenario planning. Experts were experienced academics and professionals with years of strategic foresight experience with some of them being data scientists. And all of them had used AI in strategic foresight projects.

As mentioned earlier in chapter 10, the author prompted ChatGPT to provide the weak signals of change for Argentina and Brazil. The output is attached in the appendices. The outputs from ChatGPT were the same regardless of the year to be foresighted. The ChatGPT output contained trends or megatrends of the countries in question but not weak signals of change. As the weak signals output from ChatGPT was something which were obvious and well-known issues. Nonetheless, the output of ChatGPT were similar to the drivers that were detected by EIBE students from case 2. Thus, on the outset, it seemed that the output of AI would be beneficial to novices such as EIBE students as a starting step. As expressed by the interviewees in case 2.

But experts in case 3 were of the opinion that output from AI – not specific to the context of case 1, 2, mentioned in the preceding paragraph – were more trends than weak signals. And this information would already be known to experts in the field. That is, the AI output would contain information which is obvious and not something which is novel to experts. An excerpt presented in earlier chapter is recalled here again.

“But drivers have change[d]. I think you probably get the obvious ones right. We'll end up with a list of megatrends like **** that people already know for the most part. Now, if you're in a very specific industry or business, right, that these people are gonna know that stuff like that's gonna be very obvious to them, right? It'll be almost taken for granted type of obviousness”
(P3L23, Interviews 2023).

This contrasting view draws out an important argument and nuance that AI output would be useful depending on the expertise of the participants. Novices such as EIBE students might feel that AI is a very useful tool whereas an expert in the field might not value it as much, since the output is

Thus, to answer research question 1, it does not seem that AI can enhance weak signal detection by itself. Nonetheless, there is a nuance to the answer. As the level of expertise of the participants determines the ability of AI to detect weak signals. Presently, in the eye of the expert, the output of AI doesn't seem to detect weak signals but rather just trends. Thus, not adding much value. But in the eye of novices, AI output does add value. However, by cautious and skilled deployment of AI, it can aid in scanning for weak signals.

obvious and already known to them.

11.2.2. Answering research question 2

In figure 57, under answering RQ2, the cluster consists of the following themes: Possibility of ML overcoming filters (case 1), ML as starting point (case 2), and Skilled and cautious use of AI can aid in reducing filters and challenge users to work harder at detecting WS (expert interviews). These will be presented below. Along with this, individual case themes that are important based on the judgement of the researcher for answering the research questions are also presented.

Weak signals have to pass through three filters – Surveillance, Mentality, and Power – before they are perceived as information. The discussion on these filters was presented in chapter 2/3. Considering the amount of data being generated digitally, it is invariable that humans will not have the capacity and capability to analyse all of this information. For instance the digital data growth is projected to be 180 Zettabytes (1 Zettabyte = 1 trillion Giga Byte) in 2025 (Statista, 2021). But machines have the possibility of doing this. Large Language Models (LLMs) such as ChatGPT, Gemini, etc., are examples of machines that can analyse, reduce, and present information from enormous digital data.

Participants from across the cases (1, 2) and expert interviews have expressed that AI could be used as a starting point. As mentioned previously, participants in case 1 and case 2 expressed that the digital data is being generated in vast amounts. And a person must go through a lot of irrelevant information before finding the relevant ones. This navigation for finding relevant information will invariably be affected by filters of weak signals. As it is easy to get lost in the vast amount of data.

Quoting the common saying within the computer programmers' community, 'garbage in; garbage out', is true for AI too. Unreliable data being fed will have an effect on the quality of output. More importantly, the filters are amplified as there is a danger of pre-existing biases of participants being confirmed due to biased data being fed will impact the selection of drivers. The example of AI – Tay (Microsoft), discussed earlier, is the perfect example where unreliable data affected AI. As the model was trained on tweets (now X) which contained racist, misogynistic, etc., tweets.

The quality of data will also amplify filters as the 'facts' in the training data are unverified. To an extent, it might very well be an opinion. But the AI

might output this as fact. And when the scanners of weak signals consume this, it could lead to amplifying the filters of WS.

There seems to be a tendency of people to believe in machines more than humans. The line of thinking is similar to someone saying, 'it must be right as the information is from AI'. Based on the previous discussions on unreliability of AI, and the tendency of people to believe in AI blindly, leads to a situation where filters of WS are amplified. Excerpt from case 3 interview, presented earlier, is recalled here:

"It will have a huge effect because people will not trust themselves anymore, not themselves, as those who are the researchers, those who are the organisers of a of a process and you have to defend yourself, always in in the future and we always already see that in, in in machine learning in diagnostics for example, where even physicists have to defend themselves when they did not see something that an AI detected or on the other hand we have a lot of faults, positives in detecting things that come up and then people are really why, what? What do I have if they get a diagnosis, if there is something detected like in cancer for example. But in the end, it turns out that there is nothing, but people will not believe it anymore and the same occurs in scenarios because the machine is able to detect something... to propose something... people will lose the ability and the trust in themselves"
(P3A23, Interviews 2023)

The issue of believing in AI, especially when there are false positives or hallucinations will add to the filters of weak signals. This, and considering that participants from case 1 and 2 expressed that AI could be helpful in scanning, leads to an interesting contradiction of views. Where, experts are aware and cautious of the false positives, but, as mentioned previously,

novices might believe the AI output which might contain the false positives leading to filters of weak signals being affected.

Another situation is the effect of person of influence on detecting weak signals. As Ansoff (1975) states, there is an influence from people of power on other participants. Experts believed that when people of power select or reject a driver/weak signal, due to power play these are seldom challenged by participants without such power. Even if the weak signal/driver seem farfetched. This is further exacerbated if AI output falsely detects a weak signal. As this supports and justifies their stand due to the belief that AI is right as discussed in the preceding paragraph. Interview excerpt from earlier is presented here to provide context.

"But I tend to find that there are all sorts of people that love whoever the most elite person in the room's ideas are, right, and so like if your boss comes up with the driver, you can guarantee that driver ends up in the final product, no matter how good or bad it is (P3H23, Interviews 2023)".

Thus, experts cautioned that AI must be used skilfully and cautiously. By doing so they believed that AI output could provide an opportunity to challenge participants (detecting weak signals in any project) to work harder at detecting weak signal. Further, AI is immune from taking offence to criticism, thus it is possible for facilitators to encourage participants to critique AI output in order to address the previous challenges related to filters of weak signal. Thus, indicating that AI could aid in reducing the filters of weak signals.

But the machine output needs human interpretation. In the first and the second case, LDA model was used. This model outputs a cluster of words. The interpretation of this cluster is influenced by personal views of the

participants with a possibility of disregarding information due to inherent human biases. Thus, though the machine might not be affected by biases, human's interpreting it will be. Therefore, filters of weak signals will be present whilst interpreting machine output. Participants of the group observation also expressed that information could be rejected due to personal beliefs and when information presented threatens a person's current position. From case 1, the participants were of the opinion that filters of weak signals will remain regardless of machine learning or AI.

Advancements in the field of AI led to the introduction of LLMs. These LLMs were capable of presenting outputs in natural language rather than a cluster of words as with the LDA model used in case 1 and 2. Thus, experts in strategic foresight with knowledge of LLMs were interviewed.

In case 1 and 2, participants expressed that, since the machine learning output was cluster of words, the interpretation would be affected by filters of weak signals. But with respect to LLMs, though the output is not cluster of words, the experts were of the opinion that filters would be amplified as the data used by LLMs is unreliable. And biases are built into the databases that the LLMs use. LLMs learn from the internet which consists of all varieties of data. And controlling for quality is an arduous task. Some of the content on the internet are extreme. And there is a possibility of these extreme content seeping into to the LLMs – an example of Microsoft bot, Tay, which became racist and misogynistic was presented in earlier chapters.

Further, the experts expressed, with a sense of caution, that when AI output is based on false data, it could lead to a situation where a false point of view is supported. Thus, amplifying the filters. Today, some content generated by LLMs are uploaded on to the internet which is again consumed by LLMs for training. This leads to a situation of, metaphorically speaking, a snake biting

its own tail. Which would present a danger of envisioning a false future which is based on a false present.

With people putting more faith in AI rather than humans; there is an implicit trust in AI leading to a thought that AI can do foresight and therefore the need for foresight experts is not needed. This further enhances the possibility of filters being amplified. As without experts, the quality control of weak signals detected might be compromised with a possibility of incorrect identification of weak signals.

But experts expressed some positives with respect to the use of LLMs for detecting weak signals. AI can be criticised as it takes no offence. This can be helpful as power filters exist while selecting weak signals. Further, as expressed by experts, in the future AI will be an integral part of foresight. Hence, by skilled and cautious use it can aid in reducing filters of weak signals.

Thus, to answer the second research question, during the **perceiving of weak signals** it seems that **filters do remain even with the use of AI**. And there is a possibility that **AI might amplify the filters of weak signals**. But cautious and judicious use of AI could aid in reducing filters.

Chapter conclusion

In this chapter, the answers to the research questions were provided. This was done by presenting and analysing all the cases. This chapter weaved together the analysis from the two cases and expert interviews to provide answers to the research questions. In the next chapter, the discussions of the findings from this research will be presented. Along with this the contribution of this research to theory and practice will be presented. With

any research, it is important to evaluate the quality of research. This will be presented in the next chapter.

12. Discussion and contribution

In the previous chapter, the answers to the research questions were provided. These answers were arrived at by conducting rigorous research. The method and the methodological choices for the research were presented in the earlier chapters. This chapter will revisit the research objective and research questions set out earlier. Following this, the contributions of this thesis, research implications, limitations, and future research directions will be presented.

Review of the research objectives

This research was motivated by the personal interest of the researcher on dealing with uncertainties. Through this motivation, the researcher pursued the weak signal theory proposed by Ansoff with an aim to contribute to the further development and enhancement of the theory. Within the WS signal theory, the researcher was particularly interested in the framework of filters that Ansoff proposed. Especially, if the advent of new technological advancements such as machine learning and AI would have any effect on this.

Before proceeding with the research motivation, the research gaps had to be identified through a literature review. The researcher conducted a systematic literature review (Tranfield et al., 2003) on weak signals with the aim of taking stock of the state of the art of the field. Through the literature review, the researcher was able to identify some research gaps which were presented in the literature review chapter. The relevant research gaps from the literature review are presented below.

Research Gap: Empirical research and validation are required for the quality and quantity of weak signals detected by technology-enabled methods such

as text mining and machine learning. Especially using case studies in the present timeline rather than illustrative case studies of events which have occurred in the past.

Research Gap: Empirical research on sensemaking (analysis), filters (biases), organisational factors, and personality attributes affecting the detection and the analysis of WS is needed.

This research gap was particularly important for strengthening the foundation of weak signal theory. Based on the research gaps and the research interest of the researcher, the following research questions were developed.

RQ1: How can Artificial Intelligence or Machine Learning enhance weak signal detection?

RQ2: How can Artificial Intelligence or Machine Learning alter the process of perceiving weak signals in the context of filters of weak signals?

The answers to the research questions were found by conducting empirical research as outlined in the earlier chapters. The empirical investigation was a multi-method, multiple case study and was researched using the lens of pragmatism. Semi-structured interview, observations, and survey methods were used to collect the data in case study 1. In case study 2, semi-structured interviews were conducted. And the Miro boards of MBA students from EIBE course were observed. In expert interviews, foresight experts were interviewed in a semi-structured interview.

The interview analysis was done using Thematic Analysis (TA). For comparing the Miro boards, the researcher had to innovatively develop a

comparison method. A detailed explanation of the methods and analysis has been presented in the earlier chapter.

12.1. Discussion on Findings

In this section, the researcher will present the various themes and observations not just relating to the research questions. The researcher will revisit the literature along with the findings to see how the findings relate to the literature. It is possible that the findings might not necessarily agree with the literature. Thus, a discussion between the empirical findings and the literature will enable this study to enfold the existing literature on weak signals. The discussions are primarily centred around the filters of weak signals and the possibility of using machine learning for detecting weak signals. Thus, the focus of this section is not the convergence of literature and findings. But rather, the aim of this section is to present the original contributions of this research.

12.1.1. Contribution to theory

This research looked at answering the research questions through the lens of Pragmatists philosophical stance. Thus, the emphasis was on practical utility rather than ontological reality. This is in line with the pragmatists line of thought and as (Rorty, 1998 in Johnson, 2007) states "the pragmatists criterion for knowledge is practical utility rather than ontological reality".

As discussed previously, in thematic analysis the relevance of the theme to the research objective based on the experience, reflection, and judgement on the researcher is important. Rather than based on frequency of occurrence or other quantitative cut-offs. Thus, the following themes from

the research are presented below which will contribute to the extension of the weak signal theory.

The answers to the research questions answered in the previous chapter will be discussed in relation to the extant literature. Further some themes emerged from the data collection that were not related to the research questions but contributed to the overall weak signal theory within the objective of this research.

The research questions are recalled here for providing a context and for ease of reading.

RQ1: How can Artificial Intelligence or Machine Learning enhance weak signal detection?

RQ2: How can Artificial Intelligence or Machine Learning alter the process of perceiving weak signals in the context of filters of weak signals?

Table 8: Technology approaches in literature

| Authors | Method | Data type / source |
|--|--------------------------------|--|
| Glasse (2009; 2012) | Folksonomies | Start-up map |
| Pang (2010) | Web scraping / social scanning | Online social websites, twitter, blogs, etc. |
| Thorleuchter and Van den Poel (2013); Thorleuchter and Van den Poel (2015) | Web mining | Keyword based internet crawling |

| | | |
|--|--|--|
| El Akrouchi et al. (2015) | Text mining | Various internet sources |
| El Akrouchi, Benbrahim and Kassou (2021) | LDA | |
| Yoon (2012) | Text mining | Web news |
| Lee and Park (2018) | Text mining | EBSCO host database |
| Yoo and Won (2018) | Agent based simulation (NetLogo) | Various online media |
| Vicente Gomila and Palop Marro (2013) | Tech mining | ISI WoS database |
| Park, Cho and Heo (2021) | Keyword & document similarity | Journal abstracts |
| Kim and Lee (2017) | Key word rarity | Futuristic data – future oriented opinions from online communities |
| (Kim, Park and Lee, 2016) | Key word analysis | Futuristic data – future oriented opinions from online communities |
| (Sjöblom et al., 2013) | Data mining and Clustering analysis | Aviation and health datasets |
| (Bisson and Diner, 2017) | Graph theoretical approach | Survey and expert opinion |
| Kwon et al. (2018) | Keyword network analysis | ORBIS database |
| Song, Elvers and Leker (2017) | Patent convergence | International Patent Classification data |
| Zhao et al. (2024) | Statistical | Primary data collection |
| Bzhalava, Kaivo-oja and Hassan (2024) | NLP, keywords, co-word analysis, correlation explanation | Crunchbase database |

| | | |
|----------------------------------|---|----------------------|
| | (COREX) topic modelling | |
| Ma, Mao and Li (2024) | Keyword and citation network analysis; Statistical | Academic papers |
| Xie, Ma and Li (2023) | NLP, outlier analysis, LDA for convergence and monitoring | Academic papers |
| Ha, Yang and Hong (2023) | NLP, keyword extraction, Graph convolutional network (AI) | Academic papers |
| Cheng and Sul (2023) | Semantic network analysis | Chinese social media |
| Ebadi, Auger and Gauthier (2022) | Keyword extraction, deep learning, and expert validation | Academic papers |

The first research question is related to the ability of machines to detect weak signals. In this context, table 8 above is recalled here from the literature review chapter. The papers mentioned in the table use various methods of machine learning and AI for weak signal detection. The common methods are keywords analysis, co-citation analysis, network analysis, text mining, deep learning, and natural language processing. But as stated in the literature review, the papers express the ability of their respective models by using retrospective knowledge. As in, the event has occurred in the past. As Roux-Dufort (2016, Pg 29) states that "It is always easier to attribute warning signs to an event when the final outcome is known or expected".

For instance, Ha, Yang and Hong (2023) in their paper use NLP and deep learning to detect weak signals automatically. The model's ability is justified by them using a retrospective data. Further, they use only academic journals as source of data. Where the quality of data is generally considered good. From the examples of weak signals detected by the model presented in their paper, the weak signals seem obvious and well know rather than weak as shown in table 60 below.

Table 60: weak signal extract from Ha et al (2023)

| | |
|-------------------------------|---|
| Blockchain | Bitcoin blockchain, crypto-currencies, digital currency, hyperledger, digital currencies, crypto-assets, crypto-asset, blockchain+ , decentralized ledger |
| Cyber security | Android botnet, cryptojacking, Android malware, IoT malware, Android malicious, ransomware attacks, crypto-ransomware, ransomware, locker-ransomware, IoT botnet, fileless malware |
| Problematic use of the mobile | Facebook addiction, problematic social media use, mobile phone addiction, smartphone addiction, mobile phone dependence, game addiction, smartphone dependency, problematic smartphone use, digital game addiction, problematic Facebook use, internet gaming, social media addiction, SNS addiction, nomophobia, mobile phone dependency, social media usage |

Source: Ha, Yang and Hong (2023, Pg 10)

The papers that employ AI (or ML) seem take a positivist stance that weak signals can be detected by following certain actions. And thus, there is some measure that can be used to determine whether a signal is weak or not. As Zhao et al. (2024) state, "Most existing literatures use qualitative analysis methods such as meaning construction and expert judgment to study WSEP (weak signal evolution prediction), which is too subjective. A small number of literatures use mathematical models to improve the shortcomings of strong subjectivity". This is problematic as weak signals are subjective in nature

(Ansoff, 1990). Thus, as Rossel (2011, Pg 379) states "In fact, only a few authors bother to give any clues on how to actually find them".

Nonetheless, Ma, Mao and Li (2024) have used a comprehensive framework to detect weak signals and validate it. But their main dataset is academic journals only. The same with other papers such as Xie, Ma and Li (2023); Ebadi, Auger and Gauthier (2022); and Ha, Yang and Hong (2023). And does not include social media or news reports. This might be acceptable as they use their model for a technical field such as gene editing, hypersonic, etc. As these topics might not have much information on the social media. But the ability of these framework and models to detect weak signals with respect to social and business issues is unknown. As this would require the expanding the sources by use of social media.

Since the majority of the models use academic journals, where there is a lag from submission to publication, the possible ability of these models to detect weak signals in a current timeframe can be questioned. Though some papers such as Pang (2010); El Akrouchi, Benbrahim and Kassou (2021) have used social media as source of data and news data, the validation of weak signals are missing. Essentially, going back to the question raised in the weak signal theory presented in the literature review chapter – Who interprets that these weak signals are weak signals? As, as per the papers, the line of thought is that weak signals detected are absolute. Yet, they need to be interpreted.

If the interpretation is done by novices such as EIBE students, then, the AI output could be deemed useful. As they represent the general trends of a particular situation or scenario. In case 1 and 2, interview participants expressed that the AI output could be a good starting point. From the Miro board observations from case 2, there were a lot of similarities in the output of AI and those drivers detected by the EIBE students.

But if the interpretation is done by an expert in the field, then the AI output would seem that it is generic (trends) rather than identifying the weak signals. As the experts observed, AI output was either obvious or contained information that are already known. And thus, AI is not good at detecting weak signals. And detecting weak signals required going beyond just the AI output. Further, experts pointed out that if the context was a complex social problem, then the AI output was poor in quality. Nonetheless, experts suggested that this can be used as an advantage in pushing the participants further and to work harder at detecting weak signals.

Thus, it does not seem that machine learning and AI tools can enhance weak signal detection. But there is nuance to this as the value of AI output is dependent on who is using it. If an expert is using it, then perhaps not as they seem to contain information already known. But if it is a novice who is using AI then there seems to be value in the output and seems useful as a good starting point.

Through the second research question, how do machines alter the process of perceiving weak signals (filters of weak signals) was explored. Ansoff (1990) proposed that weak signals need to travel through three filters before they become meaningful. The three filters are surveillance filters, mentality filters, and power filters. But research on filters is relatively sparse compared to weak signal detection. Some papers have discussed how filters are at play when perceiving weak signals, for e.g., Oikarinen, Salminen and Mäkimattila (2012). Rouibah and Ould-Ali (2002, Pg 137) acknowledge this by stating "Interpreting weak signs is a real problem encountered by many managers in different organisations that is closely related to the strategic decision-making process. This process is recognised as ill-structured and not adequately understood". Pinsonneault and Choi (2022) recognise this and emphasise that identifying and making sense of weak signal should be an essential priority.

Though a few papers have discussed on the filters (for e.g., see: Ilmola and Kuusi (2006); van Veen, Ortt and Badke-Schaub (2019)) most of the papers that propose machine based WS detection have ignored it. The implicit premise of the papers is that by using AI in the context of weak signals the result is unbiased. This is quite problematic for the development of the WS theory. As the general digital data contains, apart from good data, some extreme views and is subjective. Since AI is becoming embedded in almost all aspects of day-to-day life, it is important that it's (AI) effect on filters be explored. The papers from table 8 claim that their respective models were able to detect weak signals to their satisfaction. But the influence of filters was either ignored or assumed to be absent. Thus, impacting the quality of weak signals.

For instance, El Akrouchi, Benbrahim and Kassou (2021) use LDA to detect weak signals from news data from a time period before COVID pandemic to explore if their model can detect weak signals. They present an example of weak signal with the label 'Disease' as shown in table 61 below.

Table 61: LDA weak signal extract from El Akrouchi et al (2021)

| Filtered term | Similar words |
|---------------|--|
| Disease | ailment infection tuberculosis mosquito lung diagnosis respiratory asthma symptom cancer deadly_germ outbreak drug_resistant nsaid illness coli degenerative resistant anthrax antibiotic vaccine cure diagnosis infect bacterial contagious duodenoscope bacteria epidemic pesticide |

Source: El Akrouchi, Benbrahim and Kassou (2021, Pg. 09)

In the table, the label 'Disease' is considered a likely weak signal for COVID due to the cue words highlighted in bold (by the authors of the example paper). These could be considered an indication of COVID pandemic with the power of hindsight. But with the absence of hindsight, the keywords could be interpreted differently. For instance, the author could, perhaps, perceive these keywords in the above table as biological terror warfare due to anthrax being present. Thus, it seems that filters of weak signals are at play whilst deducing the keywords by people. Which has not been explored in the papers that employ machine learning methods to detect and analyse weak signals.

Participants in case 1, 2, expressed that the keywords would not be enough to make reasonable conclusions in identifying weak signals or drivers. Which supports the arguments made above. Experts were also concerned about the tendency of people believing in AI blindly. As it is well known that AI can output fictitious data and can hallucinate. This belief in AI could lead to a situation where false positives are considered as weak signals or drivers when instead it is just noise. This further exacerbates the filters of weak signal when the false positives of the AI output support the view of the participant who is in a position of power. And as expressed by experts, other participants will not challenge it and will accept it. This situation will lead to amplifying the filters of weak signal.

However, based on the expert opinions, AI output can be criticised as it will not take offence. And thus, facilitators can ask participants to criticise the AI output in order to flush out the false positives and thereby attempt to reduce the filters of weak signal.

Based on the findings presented earlier, it does not seem that AI tools would reduce the filters of weak signal. But it seems that there is a possibility that filters might be amplified by the use of AI.

The use of AI in the context of weak signals, and therefore strategic foresight, is inevitable. Considering the above, it is important that facilitators (or practitioners) use their right judgement. As the judgement impacts the quality of the weak signals. This is discussed as one of the themes.

Facilitators judgement impacts the quality and the filters of weak signals (expert interviews)

This theme is in agreement with one of the research gaps identified in the literature review chapter presented earlier. The research gap identified was:

Empirical research on sensemaking (analysis), filters (biases), organisational factors, and personality attributes affecting the detection and the analysis of WS is needed. This is particularly important for strengthening the foundation of weak signal theory.

The literature discusses about how factors such as, heuristics (Haeckel, 2004), intuition (Bertoncel et al., 2018), organisational design (Battistella and De Toni, 2012), culture (Roberto et al., 2006), etc., affect the filters of weak signals. But, apart from the above few papers discussing these factors, there was a lack of research on the effects of these factors on weak signals.

"And if we do that in a way that doesn't compromise the learning objectives of the scenario process, and that's down to how we design how we use it, then you can get a really beneficial outcome from it" (P3K23, Interviews 2023).

Even though the aim of this research was not to exclusively study the effects of these factors, through the data analysis, this particular theme emerged.

Apart from the factors motioned in the preceding paragraph, data analysis revealed that work experience and a person's background (work or educational or both) would have an effect on what that person looks for or scans for. Further personal belief systems will have an influence on what the scanner scans for. Another extension to the list of factors from the literature that affect the filters of WS are a person's language and cultural. Even though influence of culture has been discussed, research on the effect of language is missing. For instance, the ability of interpretation of an English text by a non-native English speaker could be different from that of a native speaker.

Presenting an interview excerpt as an example for the belief system:

"You know how systematic what XXXX did was you know she would. Obviously, get things together that XXXX could read it, and believe that we will be able to read as well, because XXXX was giving us this material so as an English language mainly. Some of us, you know speak other languages and read of the languages, but probably should accept that way, and it would be what these people thought was significant" (P1F21, Interviews 2021).

As facilitators of scenario planning projects are from various backgrounds. The above will affect them as well. Further, similar concerns were expressed by some of the participants in case 1 and an excerpt is presented below:

"I think so because you have a you know I think it's being influenced by also your view of the world, so if you are, for example, looking into the climate change, and you have certain opinion about climate change or know, climate change or whatever, whatever you have so your search would be, I think, from you... unavoidable bias would be maybe not you will not be open to researching the... you might be but this sort of bias can be present that is influenced by our view of the world" (P1G21, Interviews 2023).

Thus, additional factors such as, background and personal beliefs are factors that affect the filters of weak signals. As facilitators in scenario planning projects have an influence over the judgement of weak signals and drivers it is important to note that they (facilitators) may contribute to the filters of weak signals.

Based on the above, the research framework can be modified to include the themes that have emerged. This modified framework is presented below as figure 58. The thick red border with respect to the vertical rectangle denotes that machines does not seem to enhance weak signal detection. The metaphoric brick wall has increased in thickness to depict that filters seem to amplify or remain even with the use of machines.

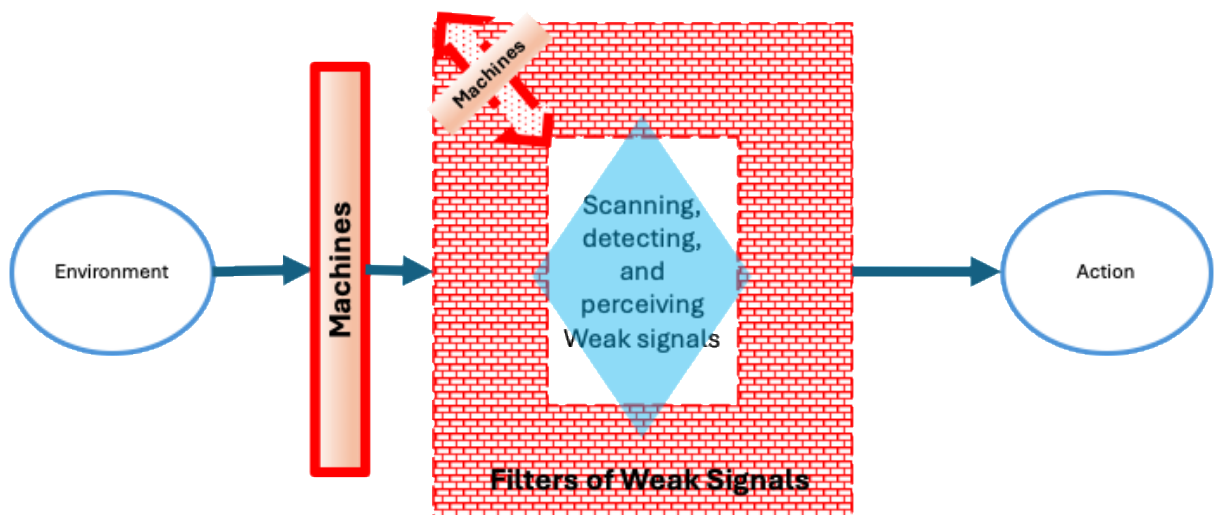


Figure 59: Modified research framework

12.1.2. Contribution to practice

In the previous section, the contributions to theory were presented. In this section the researcher will present some of the realisation through this research which might appeal to practitioners. Even though this thesis did not develop with the aim of making contribution to practice, the researcher

believes that some of the observations made through the data analysis might be fruitful for practitioners.

Foresight practitioners must develop new competencies in understanding, using, and judging AI.

As the theme suggests, understanding the nuances of how AI works and how it uses data will become an essential skill for foresight practitioners. AI is here to stay and has become part of our everyday use such as our mobile phone which use AI for various operations such as photo processing. Thus, invariably foresight will be influenced and affected by it. Therefore, practitioners must up-skill in order to stay relevant. The following excerpts from expert interviews show the opinions expressed:

"It's that it's everything else that's making that (AI) accelerate. But how we use it? We learn from it. That's (AI) gonna really significantly evolve as well and it will be a big part down to the value we extract and we just... we stop trying to use it for the wrong things... some of the things are sort of the quality of AI outputs will continue to improve the natural language... that kind of realises the ease with which we can engage with systems will improve as well and it will feel like having new colleagues in the room"
(P3K23, Interviews 2023).

"But what I do know is that we have to find a way that we need to work together, humans and machines to shape something which is more reliable or helpful" (P3O23, Interviews 2023).

"Yes, definitely say won't lose their job, but they have to change their jobs. They have to change the competencies, and they'll have to acquire new competencies" (P3N23, Interviews 2023)

"So no doubt, uh, the future, I think professionals or what Cynthia Selling called professional dreamers, We're gonna relearn and reformulate the roads and to use... To do the tools that will be here very soon or powerful are good and so on. And then I do also see another track that will affect this... if you pay attention to what is discussed among cyber security and DS information, especially in GDR politics, we start to be aware that things must be corrected, that we have to find out ways to sort out that all of this comes from security and geopolitics" (P3G23, Interviews 2023).

Prompt engineering is an essential skill needed as it affects the quality of AI output and filters of weak signals

This theme follows on from the previous theme. Prompts affect the output of LLMs and this, in turn, will affect the quality of output. This will invariably affect the detection of weak signals and drivers. Further, prompts might contain the inherent human biases which might get reflected in the AI output. Also, designing prompts for complex societal issues is extremely hard. The facilitators must be aware of this. And this is an avenue for further research. There are some advances in prompt engineering for e.g. see: Theophilou et al. (2023). But it is yet to come to the mainstream research. The following excerpts express the opinion of experts:

"But I think it's an... and also what we found from research... is that you have to do a lot of prompt engineering work to really get the... out to really get the valuable outputs" (P3B23, Interviews 2023).

"Um of that also with these Gen AI systems in sensing the prompting, you've gotta be careful again that I suppose more, more sort of unconscious biases don't creep in in the in the prompting even which may then, you know, make

the system almost think that it's gonna give you an answer that you wanna hear" (P3B23, Interviews 2023).

"But we have to learn to prompt um and to ask the right questions, because otherwise we will get a lot of noise, a lot of nonsense and a lot of misunderstandable things" (P3A23, Interviews 2023).

AI will become an essential tool in strategic foresight

Empirical research in this thesis found that AI cannot enhance weak signal detection. And would amplify filters of weak signals. But nonetheless, considering the continuous development in AI and the relative ease of its access will make it an essential tool in strategic foresight. Thus, as mentioned previously, it will become imperative for foresight practitioners to adopt and adapt AI. Along with understanding the positives as well as negatives of AI systems. The following excerpts show the opinions expressed by experts.

"But that was no idea to say that the steam engine will take so many jobs from us, so it cannot be allowed. They (AI) are here already. It will do tremendous work for us. We cannot be [inaudible] hindering the development just by saying that for foresight, for professionals, we will lose job. Ohh, we just have to change how we cope with it and work with it and utilise it" (P3G23, Interviews 2023).

"And so when you were doing a foresight process and you go through steeple analysis, you know what a steeple analysis is? Yeah. So, you go through steeple analysis and that gives you a lot of factors in loads of categories. And then I can imagine that you would have software that would go through those factors in both categories and combine them in what seemed to be" (P3J23, Interviews 2023).

AI can act as a good assistant

This theme is an extension of the previous theme. A good place to explore adoption of AI in strategic foresight is to treat the AI systems, especially LLMs, as a good assistant. As with human assistants, AI systems would improve efficiency, productivity, and save time with mundane tasks. But a good supervision of the assistant is required. That is, the AI output must be checked for factual inaccuracies and quality. Some suggestions on using LLMs were as productivity tool doing mundane tasks such as writing up reports of the scenario planning projects or writing up scenarios based on the key drivers detected. But as cautioned before, the AI must be supervised. Below are the excerpts from the interviews with respect to this theme.

"So for me I always think of ChatGPT and its evolution as a useful tool, a provocation almost like you. Some people treat that in my experience, like an additional workshop member, that they can associate with that can ask questions and has an opinion. So and I... still I'm in the headspace of AI at the minute being a productivity tool principally that if we look at any management process there's scope to create new value in new ways through these sorts of Productivity Tools and I think it comes down to the how you design that that application that is is most important" (P3K23, Interviews 2023).

"... delegates, the dull and dirty jobs, so to say to ChatGPT or anything else, and just rely on the very important work with the customers, and so on" (P3N23, Interviews 2023).

"I think about (ChatGPT) like my research assistants right now, right? Especially let's think about like undergraduate research assistants, right? I mean I have things that I want them to do. I tell them how to do it. But at no point would I ever be in a world where I don't like double check what they're doing or I don't review it for quality. I mean I just... You have to interrogate it, but it's really useful if you have something that you need to do to have an assistant take care of it. And ChatGPT is pretty quick with that"
(P3H23, Interviews 2023).

Based on the above findings from this research, revisiting Ansoff's weak signal theory, a conceptual framework is presented in figure 59 below. From the figure, AI output is affected by the data quality that is used as input. As mentioned in the earlier discussions in earlier chapters, digital data includes all variety of data – subjective opinions, racist language, high quality research, etc. Thus, affecting the AI output.

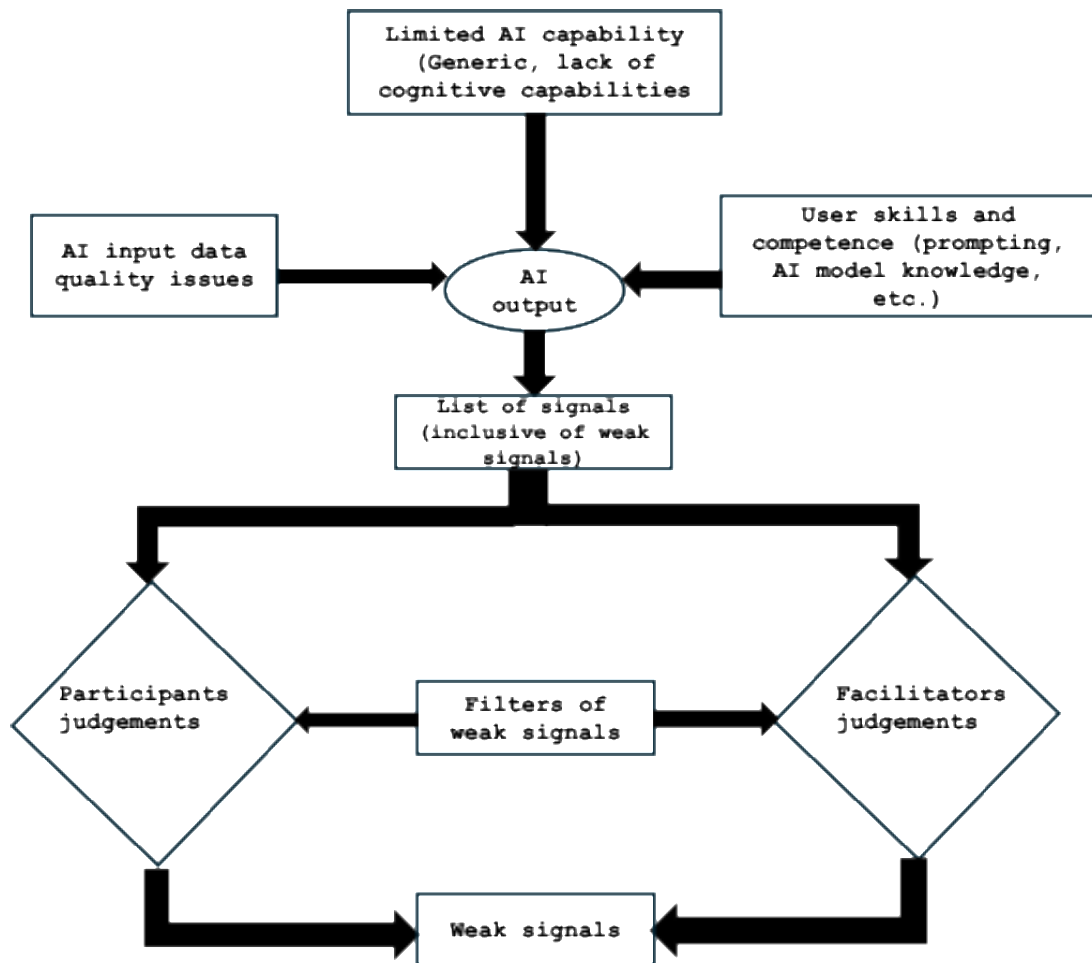
The AI models' output most often is generic and, as of now, they do not have the cognitive capabilities such as reading between the lines or understanding tactics. Further it is impossible to know how the AI models analyse data. As their analysis part works in blackbox with no access to how AI tunes itself given a set of parameters.

AI output also depends on the users' skills and competences in understanding the AI model – such as its limitations or application. Further, large language models such ChatGPT or Gemini, are directly influenced by the prompt inputted by the user. Thus, prompting skills has a direct impact on the output of the AI model. Finally, the AI outputs a list of signals which could be inclusive of weak signals.

The list of signals is interpreted or judged subjectively by the facilitators and participants to identify weak signals. As the interpretation is subjective, this

process is affected by the filters of weak signals. The effect of filters at this stage is similar to what Ansoff envisaged in the 1970s and has not changed even with the advent of technology and AI.

Figure 60: Conceptual framework: Revisiting Ansoff's weak signal theory



In this section, the theoretical contribution and contributions to practice were presented. In the next section, discussions on the quality of research of this thesis will be presented.

12.2. Research Quality

One of the most important criteria to judge good research is its quality. But judging the quality of a quality of a qualitative study is not straightforward. As qualitative research is, in itself, a subjective study. Thus, before discussing on the quality of the research conducted within this thesis, a brief discussion is presented on the common criteria used for judging the quality of research. Then, argument is presented on how most of the common criteria cannot be applied for this thesis.

The term good is relative and subjective to the perceiver. Braun and Clarke (2013), use the example of movies to explain the subjectivity of "good". The movie "The Godfather: Part II" was an Oscar award winning movie whereas "Sex and the City 2" was nominated for the worst picture. This would ideally mean that "The Godfather: Part II" was a good movie and Sex and the city was bad. But "Sex and the City 2" was enormously popular and was dubbed 'critic proof'. Thus, even though the critics rated the movie as bad, it was also good since it was accepted by so many people. This shows that quality can be either bad or good depending on who is looking at it. Translating this to research, for instance, a grounded theory (GT) research should be judged by the methodological beliefs behind that research rather than whether a person is agreeable or not agreeable with the principles of grounded theory (GT).

The criteria for evaluating good quantitative research in realist approaches are widely agreed upon. The criteria are generally applicable for evaluating

all the quantitative methods. The criteria are reliability, validity, and generalisability. In the below sections, arguments for why these criteria are not suited for evaluating qualitative research will be presented. This is followed by criteria to judge qualitative research which are similar to quantitative criteria, albeit, better suited.

12.2.1. Quantitative research quality criteria

Reliability

Reliability refers to “the possibility of generating the same results when the same measures are administered by different researchers to a different participant group”(Yardley (2008) in Braun and Clarke, 2013, Pg. 279, Yardley, 2008). This is important in quantitative research as the researcher using quantitative methods usually prescribe to the realist paradigm and are interested in developing generalisable laws. To achieve this, the quantitative researchers aim to minimise the role of the researcher. As they believe that any interference from a researcher during data collection leads to bias.

But bias is a part of qualitative research. As Braun and Clarke (2013, Pg. 279) state “The kinds of things said in an interview or a focus group, for instance, depend on the (embodied) presence and the skill of the researcher. Similarly, the types of themes or categories generated in the analysis depend on the standpoint and experience of the researcher”. Also, the qualitative interviewers generally subscribe to the views of pragmatism, relativism, or interpretivism. And thus, they give more importance to the context, meaning, and experiences. They believe that knowledge is rooted in the context and therefore cannot be removed just to address the influence of biases. Thus, it is argued that reliability is not an appropriate measure for qualitative work. As Braun and Clarke (2013, Pg. 279) state “This means that reliability is not

an appropriate criterion for judging qualitative work and procedures such as calculating the 'inter-rater reliability' of qualitative coding are problematic (because of the assumption that coding can and should be objective)".

Further validity, as mentioned earlier, carries a connotation of measurement Bryman (2012). And since measurement is not an aim of this thesis, it is not suited as a measure for judging the quality of this work.

Validity

"Validity can be defined very broadly as a piece of research showing what it claims to show"(Goodman, 2008 in Braun and Clarke (2013, Pg. 280)).

Simply put, how accurately does a research capture the reality. This is a problem with ontological paradigms leaning towards nominalism where there is no one reality. The researcher of this thesis prescribes to the pragmatists paradigm where the belief is that reality is too dynamic and thus impossible to capture. Hence, the concept of 'validity' becomes problematic.

There are three common validities: construct validity, internal validity, and external validity.

Construct validity

Construct validity is concerned with the data collection measure. That is how well the defined measure actually measures what a particular study aims to measure. And if the result from this measure can be generalised to a wider construct (Braun and Clarke, 2013).

Internal validity

Internal validity is related to causality. That is, whether the effects identified are indeed caused by the variable(s) and not due to some other factor (Braun and Clarke, 2013).

External validity

External validity is concerned with generalisation. That is if the results from a study sample can be applied to the population (Braun and Clarke, 2013). Even though the above three validities are considered as the standard for good quantitative research, applying these to qualitative research in general and particularly to this thesis which is based on multi-method qualitative research is problematic. The reason for this has been presented at the beginning of this discussion on validity. But then the question arises as to how to judge the quality of qualitative research. As Yardley (2017, Pg. 295) rightly states "So if scientific criteria for valid knowledge production are inappropriate for qualitative research, how is it possible to demonstrate that a qualitative study has been carried out to a high standard and generated useful knowledge?" As mentioned earlier, this will be addressed in the later section.

Generalisability

Generalisability is whether a result from a study can be applied to a different population. There are debates, for and against, surrounding whether generalisability applies to qualitative research. For e.g., some researchers have argued that generalisability is not applicable to qualitative research due to the 'context bound' knowledge generated from the investigation (Braun and Clarke, 2013). Others have argued that qualitative research can or has the potential for generalisation but not in the same way as quantitative methods. As Yardley (2008 in Braun and Clarke (2013), Pg. 281)) states "there would be little point in doing research if every situation was totally

unique, and the results in one study had no relevance to any other situation!”.

Thus, to address this, Goodman (2008) introduces a flexible approach to generalisation. Goodman, in the context of discursive work, argues that the generalisability of qualitative work should not be judge as the same as statistical generalisability but rather as flexible generalisability. Since, in qualitative analysis, language is flexible and interpretation being subject to change, therefore whilst seeking generalisability, sensitivity to the context and language should be considered.

Considering that the above, quantitative criteria such as reliability, validity, and generalisability is unsuitable for qualitative research. It is nonetheless important to judge the quality of qualitative research. In the following section, the qualitative criteria for judging research quality will be presented.

12.2.2. Qualitative research criteria

Guba and Lincoln (1989);Lincoln, Lynham and Guba (2011) proposed ‘credibility’ in place of internal validity; ‘transferability’ in place of external validity; ‘dependability’ in place of reliability; ‘confirmability’ in place of objectivity. Table 62 replicated from Saunders, Thornhill and Lewis (2015, Pg. 206), shows each of these criteria and their respective meaning.

Table 62: Qualitative research quality criteria

| Criterion | Definition and techniques to achieve each criterion |
|----------------------|---|
| Dependability | This is the parallel to reliability. Dependability means ensuring that records are kept of all the changes; to produce a reliable/dependable account of the research that may be understood and evaluated by others |

| | |
|------------------------|---|
| Credibility | <p>This is the parallel to internal validity. Emphasis is placed on ensuring that the representations of the research participants' socially constructed realities actually match what the participants intended. This can generally be achieved through triangulation</p> |
| Transferability | <p>This is the parallel to external validity or generalisability. Transferability refers to "the extent to which (aspects of) qualitative results can be 'transferred' to other groups of people and contexts" (Braun and Clarke, 2013, Pg. 282). The key factors that determine transferability is to describe the specific context, participants, settings, and circumstances of the research in depth. This description in detail would help another researcher evaluate if the research is transferable to another context or research. In transferability, the burden of decision to transfer the results of one research to another lies with the prospective researcher rather than the original researcher.</p> |
| Confirmability | <p>This criterion is not directly related to the quantitative criteria. But the researcher must display that they have acted in good faith. And it should appear that they overtly allowed personal values or theoretical inclinations to influence the research and findings derived.</p> |

Source: Adapted from Saunders, Thornhill and Lewis (2015, Pg. 206) and Bryman (2012)

In the context of this thesis, as with any research, it is important to judge the rigour of qualitative research. For this, the above-mentioned qualitative criteria will be evaluated against this research. And is presented in table 63 below.

Table 63: Qualitative research criteria

| Criterion | Definition and techniques to achieve each criterion | Typical actions to satisfy criteria | How this was achieved | Relevant chapters |
|----------------------|---|--|--|-------------------|
| Dependability | This is the parallel to reliability. Dependability means ensuring that records are kept of all the changes; to produce a reliable/dependable account of the research that may be understood and evaluated by others | Research analysis through proper record keeping of: - Interview transcripts - Audio recordings - Researcher notes | In-depth explanations were provided on how the interviews were conducted and recorded. The context of the case studies was also presented in-depth. All the recordings were digital, and the transcript stored digitally. The interview protocols have been attached in the appendices. The transcripts itself cannot be shared as it must remain confidential due to ethics declaration made to the participants. | 7 |
| Credibility | This is the parallel to internal validity. Emphasis is placed on ensuring that the representations of the research participants' socially constructed realities actually match what the participants | - Different views through multiple inputs (multiple case study) | Multiple views points were captured through this research. Project participants (SBS 2035); Group observations; | 8, 9, 10 |

intended. This can generally be achieved through triangulation

MBA students (EIBE); Foresight experts

Transferability

This is the parallel to external validity or generalisability. Transferability refers to "the extent to which (aspects of) qualitative results can be 'transferred' to other groups of people and contexts" (Braun and Clarke, 2013, Pg. 282). The key factors that determine transferability is to describe the specific context, participants, settings, and circumstances of the research in depth. This description in detail would help another researcher evaluate if the research is transferable to another context or research. In transferability, the burden of decision to transfer the results of one research to another lies with the prospective researcher rather than the original researcher.

- In depth sample description (case)

A thorough and in-depth explanation along with the context of each of the case was provided. E.g., Participants profile, demographics, etc. This should provide sufficient information for another researcher to evaluate if this research is transferable to another context.

7

| | | | | |
|-----------------------|---|-----------------------------------|---|---|
| Confirmability | <p>This criterion is not directly related to quantitative criteria. But the researcher must display that they have acted in good faith. And it should be apparent that they did not overtly allow personal values or theoretical inclinations to influence the research and findings derived.</p> | <p>- Methodological soundness</p> | <p>The methodological choice of pragmatism was presented. And the choice of the chosen methods was presented. Further the researcher received substantial research training through various modules and workshops conducted to support PGRs by the University. Along with this, the researcher actively discussed research ideas with peers and academic colleagues to enhance his own knowledge.</p> | 5 |
|-----------------------|---|-----------------------------------|---|---|

Another commonly accepted criterion for evaluating qualitative research is Triangulation.

Triangulation

Triangulation is an idea based on the methods used by sailors during pre-gps/radar era. These sailors used triangulation process to determine the location or distance of an object by using independent measures from typically three separate locations or objects to provide an accurate reading. This method was used by people to navigate on sea and land before the convenience of modern navigation (Easterby-Smith, 2012).

The same concept was borrowed by qualitative researchers and applied to qualitative research. That is using two or more methods of data collection or sources of data to examine the same phenomenon. So as to get as close to the 'truth' of the study as possible (Bryman, 2012; Easterby-Smith, 2012). But only a realist qualitative researcher can arrive at the 'truth'. As researchers with other philosophical views either believe that truth is simply not accessible or that truth does not exist.

Some qualitative researchers view triangulation to strengthen the analysis and for getting a richer or fuller story rather than an accurate story (Smith, 1996). A similar argument is put forth by Ussher (1999, Pg. 43) to advocate multi-methods, "it is only when we put the different pieces of the jigsaw together that we see a broader picture and gain some insight into the complexity [of a research]".

The researcher of this thesis has used multi-methods in similar thought to Ussher; using different methods to see the bigger and richer picture. The researcher has used, survey, semi-structured interviews, participant observation, classroom observation, workbook (SBS 2035) and Miro board

observation (EIBE, group observation, and SBS 2035). Table 64 below shows how triangulation was achieved.

Table 64: Triangulation

| Criterion | Typical actions to satisfy criteria | How this was achieved | Relevant chapters |
|----------------------|--|--|-------------------|
| Triangulation | <ul style="list-style-type: none"> - Literature review - Multiple sources of data collection | A systematic review of the literature was taken up to identify the relevant gaps. This was then compared with the findings from the data analysis. Multiple viewpoints through different case studies were analysed from the data collected – EIBE Miro boards; Group observation, Workbook (SBS 2035); semi-structured interview. | 3, 7 |

Having established the research questions through literature review, the researcher designed a multiple case study. The first case study was a scenario planning project (SBS 2035) in the Strathclyde Business School. The researcher collected and analysed data from survey, semi-structured interview, Miro boards, and workbook (drivers). The researcher then conducted a group observation where the group were tasked with labelling the machine learning output within the context of SBS 2035. The next case study was in the context of executive MBA student studying the EIBE module. As part of this, the researcher employed semi-structure interviews, Miro board observations, and in-classroom observation (virtually through zoom). Finally, the findings were discussed in relation to the extant literature as an additional source for triangulation.

Contribution to theory and practice

As mentioned earlier, one of the important parts of a good research is theory. And the main aim of research should be theoretical contribution (Ashkanasy, 2016). Theoretical contribution of research is usually done either by generating or extending theory (Bryman, 2012).

Table 65: Research contributions

| Criterion | Techniques to achieve criterion | Typical actions to satisfy criteria | How this was achieved | Relevant chapters |
|-------------------------------|---|--|--|-------------------|
| Contribution to Theory | | | Through thematic analysis of data, key themes with respect to the ability of AI to enhance weak signal detection were identified. And contributed to the critiques of using AI models for weak signal detection within the weak signal literature. | 8, 9, 10, 11, 12 |
| | What is being added to what is already known? | <ul style="list-style-type: none"> - Extending theory - Confirming existing theory - Identifying new conjunctions of previously distinct theories or disciplines - Advancing a methodology - Grounded theory generation - Disproving null-hypothesis | Weak signal theory was proposed by Ansoff during a time when AI was not being used and digital data was absent. Key themes relating to the processing of weak signals (filters of weak signals) whilst employing AI were identified as part of revisiting Ansoff's theory of weak signals. | |
| | What is the theoretical basis? | | | |
| | How do the findings enfold literature? | | Thus, this research achieved contribution to theory by extending theory. Through extending the weak signals theory by incorporating AI and generation of insights. | |

| | | | | |
|-------------------------------------|--|----|---|----|
| Contribution to Practice | Do research implications and conclusions acknowledge policy makers or practitioners to assist them in making decisions on business or social issues? | -- | Key themes were identified with implication for practitioners such as AI can act as a good assistant; prompt engineering skills is essential whilst using AI as output quality is determined by the quality of input; developing an understanding of the working of AI is essential as AI will inevitably become part of strategic foresight. | 12 |
|-------------------------------------|--|----|---|----|

Apart from theory, Yardley (2000) suggests that 'impact and importance' should be one of the criteria for evaluating research. It means that a research must have some significance and impact on the community and for practitioners within the research context (Bryman, 2012). Hence, both the contribution to theory and practice is shown in table 65 above.

12.2.3. Research Rigour

In general, research must display good rigour and skill of the researcher. The researcher of this thesis was trained formally by the university's PGR training modules. Some examples of the modules are Introduction to research methods, Introduction to quantitative research, Advanced qualitative research, Research philosophy, etc. The modules were led by senior academics with substantial research experience and knowledge. Further, by attending departmental seminars (including invited speakers), PGR seminars, and other research events hosted by the university, the researcher was able to develop the necessary skills and knowledge to conduct high-quality research.

The literature review presented in the earlier chapters was submitted as a conference paper to BAM conference. It was accepted as a full paper.

The purpose of this research was to produce reliable and robust answers to the research questions posed. As evaluated above, this research conforms to the criteria of good quality research and has been conducted using best practises and judgement.

Chapter conclusion

In this chapter, the research objectives were revisited and the contribution to theory and practice were presented along with revisiting literature.

Arguments were presented for selecting the right criteria for evaluating the quality of research. Against which the quality of this research was evaluated and a justification for the evaluation criteria were presented.

The following chapter will be the concluding chapter where research conclusion will be summarised followed by limitations and future research directions.

13. Conclusion

In the previous chapter, the research contributions of this doctoral thesis were presented. And the research quality was evaluated against established criteria to show that this research was of high quality. In this chapter the conclusion of this research will be presented by discussing the key points from earlier chapters and presenting the final research conclusion. This will be followed by limitations and future research directions.

13.1. Research conclusion

This research began with an aim to revisit Ansoff's weak signal theory (WST), which was proposed in the 1970s, in today's era especially through the lens of technological advancement. The weak signal theory was especially relevant as the world was exposed to a turbulent, uncertain, and dynamic environment due to the COVID-19 pandemic. Numerous scenarios were generated during the pandemic and there were questions on the quality of these mass-produced scenarios (Cairns and Wright, 2020; Crawford and Wright, 2022). Even though there are some recommendations for developing good scenarios, there are very few recommendations on WS, especially, in seeking, processing, and analysing. Thus, this thesis sits in the right time frame for providing insights into WST which could enable developing quality foresight.

Before delving into the research, it was important to investigate the development of weak signals from its initial proposal (by Ansoff) till present. A systematic literature review (SLR) was conducted to take stock of the literature till date. The analysis of the literature paved way for identifying the research gaps. Based on the research gaps, the research questions were

framed to enable a structured and disciplined research. The two research questions are:

RQ1: How can Artificial Intelligence or Machine Learning enhance weak signal detection?

RQ2: How can Artificial Intelligence or Machine Learning alter the process of perceiving weak signals in the context of filters of weak signals?

A summary of the key points from the SLR presented below.

The literature review began with the analysis of the definition and theory of weak signals. Even though the definition has been improved by various scholars and is heading in the right direction, there is a need to make it more robust. Next, the literature on the methods for the detection of weak signals were analysed. It was found that the suggested methods were in need of further evaluation, especially the methods which used machine learning and AI.

The next stage in the literature review was the analysis of weak signals. Ansoff proposed the concept of filters of weak signals. The research gap that was found in this analysis was that *empirical research on making sense (analysis), filters (biases), organisational factors, and personality attributes affecting the detection and the analysis of WS is needed. This is particularly important for strengthening the foundation of weak signal theory.*

The final stage of the review was on the application of weak signals. The research gap here was that there was a need to explore further on the pragmatic benefits of weak signals in areas other than futures and foresight fields such as terrorism.

To answer the research questions, the researcher based the methodology using Pragmatism. As this was in-line with the researcher's beliefs. The methodological arguments were presented in the methodology chapter.

The research was conducted in three phases and the research was a multiple case study. The three phases were conducted in different timelines which was clarified in the introduction of chapter 7. In case 1, data was collected from survey, semi-structured interview, and participant observation. The tentative findings were presented to an expert review panel, and the panel recommended that this thesis would benefit from additional data collection. This led to case 2. Here, data was collected through semi-structured interviews and "Miro" board observation. The details of the data collection methods were presented in the data collection chapter. In the final phase, experts were interviewed to ensure that data collection was heterogeneous and that it would lead to deeper and richer answers to the research questions.

Transcripts were generated from the semi-structured interviews. And they were analysed using the Thematic Analysis. The themes from the analysis were presented in the data analysis chapters for the respective case. The observations from the group were also reported in the analysis chapter. For comparing the drivers from the Miro board with that of the machine generated drivers, the researcher had to come up with an innovative method for analysis. This was presented in-depth in the analysis chapter.

The analysis done was used to answer the research questions set out earlier as well to discuss the contributions of this thesis. Based on the analysis, for the first research question, it did not seem that machines could enhance weak signal detection by itself. But many of the research participants were of the opinion that machine learning could serve as a good starting point. For the second research question, it did not seem that machine could lower the

filters of weak signals. And there seemed to be a possibility that machines could amplify the filters. But a cautious, judicious, and skilled use of AI/ML could aid in overcoming filters of weak signals and challenge users to look harder for detecting weak signals.

To summarise this thesis:

The Motivation: The research questions that thesis attempted to answer were – How can AI/ML enhance weak signal detection? And, how can AI/ML alter the process of perceiving weak signals (filters of weak signals)?

Addressing these research questions was important because even though some papers have proposed the use of machine learning within the context of weak signals, the effects of ML on filters of weak signals was not explored. Further, the ability of ML to enhance the detection weak signals was not explored. With the ever-increasing use of technology addressing the above research questions became even more important.

The Findings: Based on the analysis weak signal filters seem to remain even with the use of machine learning. With a possibility of filters being amplified. And machines do not seem to enhance the detection of weak signals.

The Contributions: Through thematic analysis of data, key themes with respect to the ability of AI to enhance weak signal detection were identified. And contributed to the critiques of using AI models for weak signal detection within the weak signal literature. Weak signal theory was proposed by Ansoff during a time when AI was not being used and digital data was absent. Key themes relating to the processing of weak signals (filters of weak signals) whilst employing AI were identified as part of revisiting Ansoff's theory of weak signals. Thus, this research achieved contribution to theory by

extending the weak signals theory by incorporating AI and generation of insights.

Key themes were identified with implication for practitioners such as AI can act as a good assistant; prompt engineering skills is essential whilst using AI as output quality is determined by the quality of input; developing an understanding of the working of AI is essential as AI will inevitably become part of strategic foresight

Thus, the key conclusion from this research is:

Revisiting Ansoff's weak signal theory in the present timeline; Ansoff's weak signals and filters framework (published in the 1980s) has not changed even with the advancements in technology. Machines by itself do not seem to enhance weak signal detection. But there is a nuance to this as the value of AI output is dependent on who is using it. If an expert is using it, then perhaps not as they seem to contain information already known. But if it is a novice who is using AI then there seems to be value in the output. Filters do remain and, at times, seem to be amplified with the use of machines. This could be as machines do not have cognitive capabilities as humans.

But by cautious, judicious, and skilled use of machines, it could be used as a good starting point for information gathering. Additionally, because of ever-growing digital data being generated on weak signals, machines can aid in analysing and structuring data.

13.2. Limitations and Future research directions

In the previous section a conclusion of this research was presented along with key findings. In this chapter the limitations of this research will be discussed, and future research directions will be presented.

13.2.1. Limitations

As with any research, this research is not exempt from limitations. And the recognition of limitation adds strength and validity to research. The first limitation is with the choice of the machine learning method. For this thesis the machine learning methods used was Latent Dirichlet Allocation (LDA) and Large Language Models (LLMs). Even though these are commonly used algorithm, there are other methods such as network analysis, co-citation analysis, etc, which have been proposed for weak signal detection. Each model has its respective strength and weakness. And adopting all the models into this thesis would render the thesis too big to realistically manage and complete. Especially given the time limit on PhD completion, it is important to recognise the limitation of achievable scale when conducting research. Nonetheless, these could be evaluated for detection of weak signals and its impact on filters of weak signal as an agenda for future research.

The second limitation is that this research could have been conducted using quantitative methods. AI and human "Performance" could have been measured and compared in a hypothetico-deductive study. Further AI's ability to "Enhance" (or not) could have been measured. Performance would require an interpretation of better than something or worse than something. And that something would be the benchmark. Thus, inherently there is some implication of measurement.

Similarly, the word 'enhance' would also need an interpretation of measure as to the degree of impact. This leads to the question of how to interpret performance with respect to AI tools compared to humans. As, this would

require the expertise of psychologist (measuring performance/Impact), AI engineer (evaluating AI models) and foresight expert. Though developing these measures and evaluating “enhance” and “performance” would make novel contribution to the field of weak signals research, it was not aligned to the methodological choices of the researcher. Further, the researcher did not have training in psychology or AI engineering to develop measurements for the variables. Thus, this quantitative approach was not considered.

The third limitation is with respect to the data source used for machine learning. It is well known and common knowledge that machine learning efficiency and performance improves with the amount of data available. The researcher had used a website: <https://explorer.mediacloud.org/#/home> as a data source. The said website, media cloud, would give a list of URLs of news websites which contained the keywords which the user inputs. For the SBS2035 machine learning modelling, the researcher had used this website as source for URLs. The researcher then using python scripts scraped the textual data from the URLs to be used in machine learning.

Unfortunately, by the time of modelling the machine learning model for the EIBE cases, the media cloud website was down, and the data was not available. The researcher lost a major source of data for the model. This might have affected the quality of the model but there is no certain way of knowing this.

Method for analysing Miro boards observation with respect to machine learning output.

One of the aims of this research was to investigate if machines enhance weak signal detection. But to do so, the researcher could not find any tools or methods within the existing literature where two sources of outputs (weak signals) have been analysed with respect to each other. Nonetheless, this

was an important analysis that needed to be made since there were literature promoting the use of machine learning for weak signal detection, for e.g., see: Ha, Yang and Hong (2023).

Since there was no tool or method available, the author had to improvise and be innovative in developing a process for comparison. The details of the method for comparison are presented in the earlier chapter. The proposed process was able to tackle the subjectivity in the drivers named by the humans as well as the subjectivity of the labelling of the drivers detected by the machine. Thus, allowing for making meaningful analysis between the machine detected drivers and human detected drivers. This process can be explored by other researcher for their similar studies. This would invariably lead to amendments and improvements to this process.

The findings of this research are purely applicable to these cases within this research. This could lead to criticisms that this is insufficient to generalise the findings. But as mentioned earlier, generalisation is not in line with the methodology of this research. The thought process behind generalisation is that reality can be accessed and is generally considered a realist belief system. On the contrary, the researcher believes in the pragmatism philosophical view that reality is too dynamic to be accessed.

But the researcher is aware that there are other researchers prescribing to other philosophical views. Thus, by applying the machine learning methods to other cases and circumstances, the knowledge can be advanced. Which would thereby strengthen the debates and critiques surrounding weak signals.

Another criticism that the researcher might face is with respect to the method. Even though justification was given regarding this in the methodology chapter, there is a possibility that other researchers might feel

that experiment method would have been appropriate. There is no denying that experiment approach could be used in this situation to address the research problem. But using a method entails two important criteria – access, resources, and researcher's skills.

For this research these criteria were against the researcher. The researcher did not have access nor the budget to conduct an experiment. Further, an experiment in this setting would have required the researcher to have been trained in the field of psychology to come up with measurable parameters to measure whilst conducting the experiment. During initial stages of this research, the researcher had considered employing the experiment approach. But after some discussions with experts (academics within the university who were well versed with experiment method), the researcher was advised against using experiment due to lack of resources and researcher's skills. Thus, it was decided that experiment was unsuited for this research.

Another criticism that might arise is that the interview data were from just three case studies. This would imply that it was necessary to gather data from multiple case studies. When numbers are involved, where to stop is a subjective one. That is, if one is not enough, is five enough or ten or fifty? Choosing the right number is a trade-off between depth and variety. The researcher chose to go deeper rather than to cover a wider variety. The researcher conducted nine interviews from case 1, three from case 2, and fifteen from expert interviews. Along with this, artefacts were observed, and a group was observed. Thus, capturing in-depth and varied views.

The data interpretation of the interview and the data from observations was a subjective one. As with any qualitative research, interpretation is indeed subjective and therefore if the data of this thesis were to be interpreted by a different individual, the result might differ. But the researcher is of the belief

that even though the result might differ, the difference would be very minimal. As the researcher, through his research on filters (broadly biases), was very much aware of how biases might affect his interpretation of the data. The researcher thus consciously made sure that the data interpretation was not influenced by his personal opinion. Further, the researcher had received rigorous and high-quality training in research methods (e.g., advanced qualitative methods module) as part of the doctoral studies which was provided by the university. Due to this training the researcher was able to maintain a high rigour of research quality. But the researcher does acknowledge that interpretation is subjective and can differ from people to people.

13.2.2. Future research directions

Most of the limitation of this research can inspire future research agendas. The author of this thesis would like to set an agenda for his own future research based on some of the limitations from this research as well as by drawing inspiration from his exposure to other fields.

The first and foremost is to conduct a simple experiment where the control group would detect drivers using the status-quo human centric methods. The treatment group will be given the machine learning output as their starting point. It will be interesting to explore the differences, if any, in the resulting scenarios from the respective methods. For the experiment research, the following research proposition will be used for setting the research agenda:

Proposition 1. Using machine output to detect weak signals will not improve the discovery of surprising signals.

Proposition 2. Humans can detect weak signals better than ML/AI

As mentioned in the limitations, the experiment approach would require developing measures in order to conduct the experiment. The measures would be a novel contribution to enhancing the field of weak signals. A collaborative research group involving experts from the domains of Psychology, Computer science, and foresight would be formed to aid in developing the measures and to ensure the AI systems performance are measured accurately. The experiment would involve three participant groups; first would be a control group where the weak signals are scanned as part of scenario planning exercise using human centric methods such as desktop research (using LLMs such as ChatGPT will be forbidden). Here the list of weak signals detected, and the final scenarios will be recorded.

The second group and the third group will be the treatment groups, where the participants will be allowed to use LLMs for identifying weak signals as part of scenario planning exercise. The weak signals detected by these groups and their respective final scenarios will be compared with that of the control group. And this comparison should allow for deduction to answer the propositions. It should be noted that this future research agenda is in very early stages and the method mentioned above could be changed significantly based on the recommendations of the collaborative research group discussions.

As future research, to deduce if AI does "enhance" weak signal detection, a survey will be designed using ordinal questions. The survey will consist of human generated weak signals and AI generated weak signals. And the survey participants will be asked to answer the survey by making comparisons. One way forward for this survey research would be to conduct a Delphi survey (Linstone and Turoff, 1975).

Fatigue was expressed by participants in group observation. This has been seldom explored within the weak signals literature. Thus, the next proposition will be based on exploring aspects of fatigue and quality of drivers with the introduction of machines into the context. This would again be a collaborative research as measuring fatigue would require expertise in the field of psychology.

Proposition 3. Using machines will reduce the fatigue of participants whilst scanning for weak signals. And thus, affecting the quality of signals detected.

Two relatively new methods of machine learning research have come into the fore which are not yet commonly applied methods – Text to image deep learning, deep learning based natural language analysis, and multi-modal sentiment analysis methods. The names of the methods very clearly imply what the algorithms do. To the best of the knowledge of the author, these methods have not been used or have been partially used in the context of weak signals. The applications of these algorithms will open up new avenues of research, especially with respect to filters of weak signals. Some of the potential research questions are:

- How will the introduction of images by converting text documents to images affect the processing and exploring weak signals and in turn affect the scenarios being developed?
- How will the images introduced by machine learning (AI) affect the filters of weak signals?
- How will the summarised text using the text summarisation affect the filters of weak signals as well as the scenarios being developed?

In conclusion, the above propositions and research questions will open new avenues of research. This would not only address some of the research gaps in the literature but will also contribute to the foundations on accepting and implementing ML & AI methods within weak signal research and scenario planning.

Chapter conclusion

In this final concluding chapter, the research conclusion, limitations of this thesis were presented. Inspired by the limitations, the future research agendas were presented which included exploring the research propositions and research questions proposed above.

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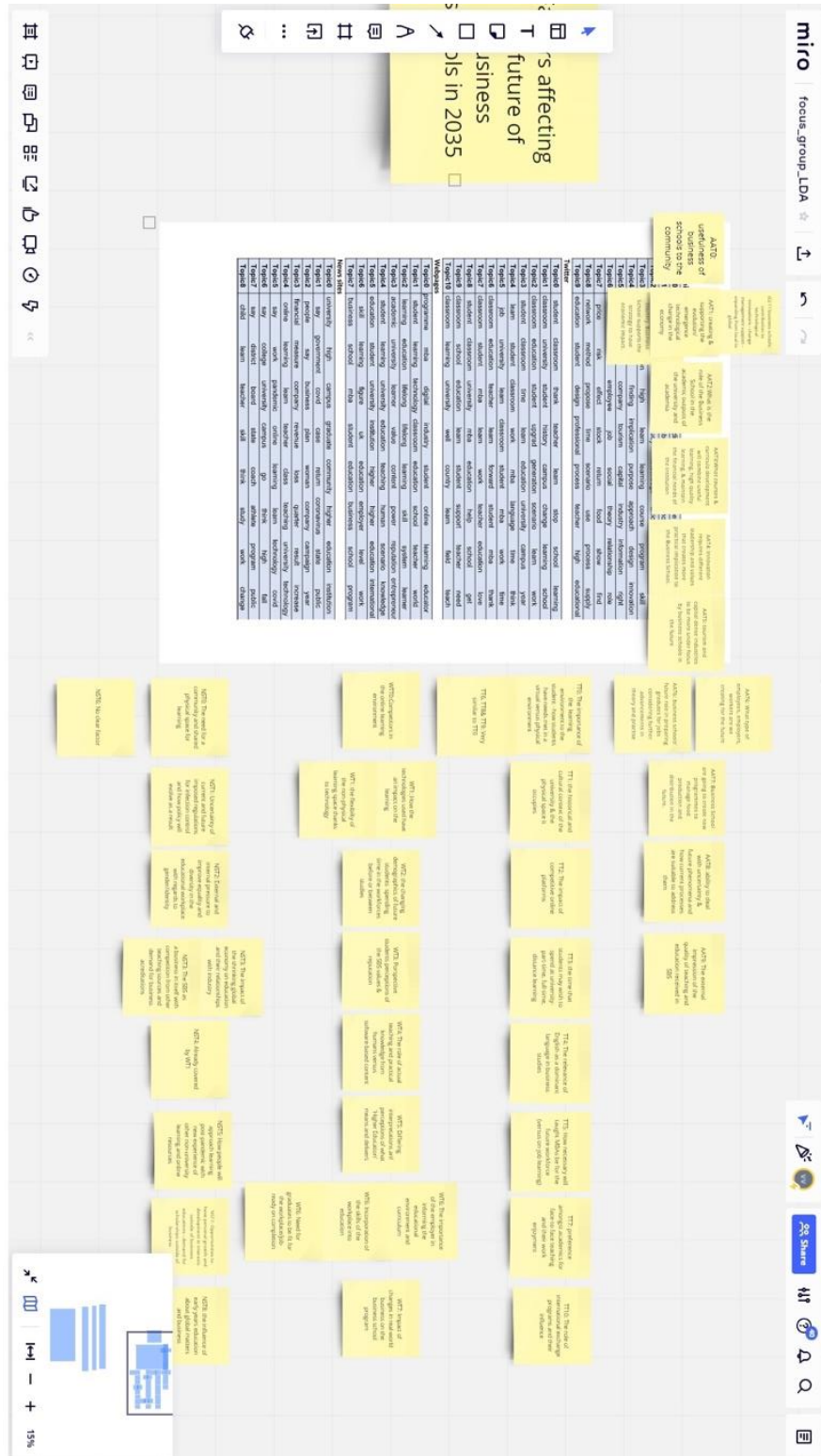
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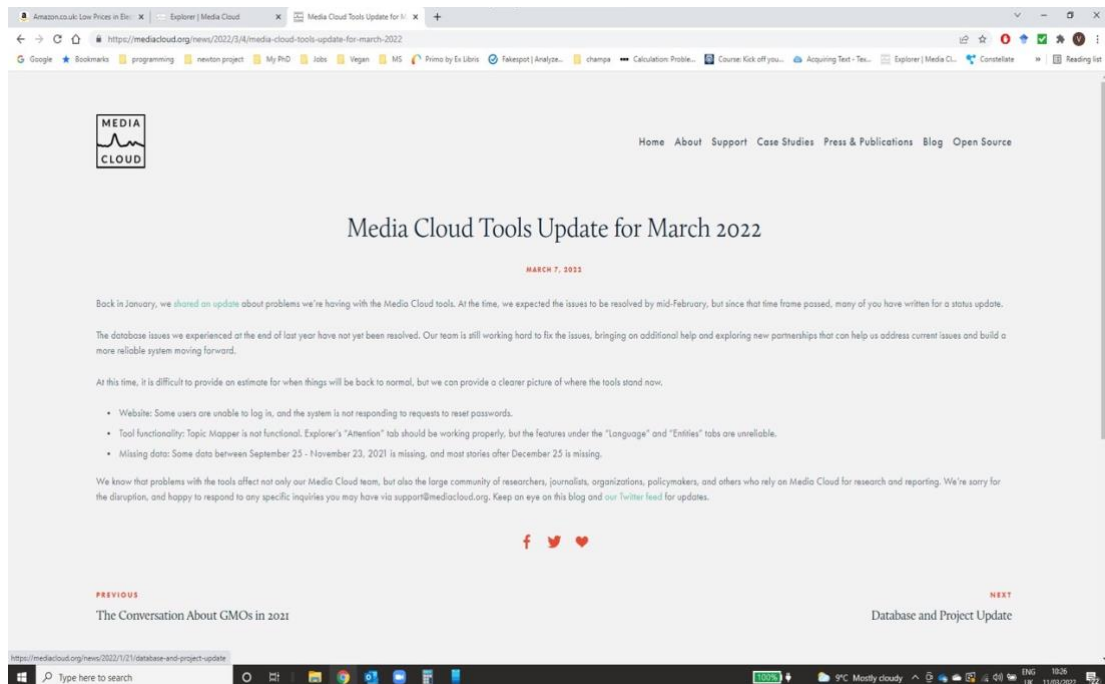
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15. Appendices

15.1. Group observation – Miro board screenshot



15.2. Media cloud blog screenshot



15.3. Machine learning output coding

15.3.1. Argentina

| word 0 | word 1 | word 2 | word 3 | word 4 | word 5 | word 6 | word 7 | word 8 | word 9 | word 10 | Label |
|----------|--------|-----------|---------|--------|--------|------------|--------|-----------|-----------|---------|--|
| model | within | different | study | record | group | analysis | showed | patagonia | important | | clothing range/ consumer pattern/ research |
| american | latin | study | country | higher | year | associated | level | author | latin | | education / level of education |

| | | | | | | | | | | | |
|---------------|--------------|------------------|----------------|-------------|---------------------|---------------|-----------------|--------------|-------------------|--------------|---|
| area | stud y | amon g | count ry | sour ce | infor matio n | value | impact | appro ach | show | | study / approac h to study/ research |
| count ry | auth or | latin | popul ation | rate | analys is | based | study | year | data | | populati on |
| south ern | even t | analys is | centra l | usin g | also | time | result | elsevi er | based | | event analysis / research |
| forest | resea rch | chilea n | know ledge | spec ie | range | publi shed | record | data | andes | | species/ environ ment/ change climate |
| regio n | wate r | chang e | clima te | resu lt | condit ion | high | proces s | activit y | period | | climate change |
| speci e | sout h | distrib ution | south ern | gen us | area | foun d | data | ameri can | forest | | environ ment/ forest/ region |
| produ ct | expo rt | servic e | trade | bene fit | level | plan | report | key | see | | export/ commere ce/ trade |
| area | goal | relate d | suppo rt | prov ide | priorit y | covid | develo pment | strateg y | interna tional | | covid strategy/ covid support/ develop ment |
| mem ber | secto r | also | make | mar ket | trade | strate gic | first | bueno s | aire | officia l | sector perform ance/ emphasi s on trade/ market strategy |
| challe nge | ever y | syste m | two | peo ple | growi ng | leadi ng | see | take | project | | challeng es with system/ |

| | | | | | | | | | | | |
|------------|-----------|-------------|----------|---------|-------------|----------|-----------|------------|---------|---------------|---|
| | | | | | | | | | | | people/ leadership |
| need | national | time | work | find | vaccination | know | today | problem | also | | problem with work/ national vaccinations/ |
| economy | measure | information | policy | program | since | new | resource | financial | law | | economic performance/ economic policy performance/ law/ legislation |
| many | home | buenos | aire | global | covid | vaccine | death | important | region | number | regional healthcare/ covid/ covid vaccine |
| population | argentine | fund | south | america | four | activity | covid | strategic | related | public | population/ covid strategy/ funding for managing health |
| service | billion | debt | take | largest | date | check | agreement | investment | first | | debt servicing/ investments/ |
| united | state | president | regional | history | one | include | public | global | working | international | American influence/ global |

| | | | | | | | | | | | |
|-----------|-----------|-----------|---------|--------|---------|-----------|-------|------------|-----------|-------------|--|
| | | | | | | | | | | | approach/ historical relations |
| argentina | they | year | one | vote | left | always | put | world | love | | voting |
| want | come | would | doe | time | say | you | much | best | give | | |
| country | people | the | vaccine | photo | million | without | going | government | published | | government vaccination/ people getting vaccinated |
| new | buenos | aires | death | buenos | aires | live | the | case | this | coronavirus | covid death/ covid life |
| the | brazil | argentine | cup | world | chile | argentina | team | mexico | messi | | football |
| help | inflation | venezuela | know | place | america | euro | blue | country | need | | inflation / economy/ effect from Venezuela |
| argentine | like | already | see | know | also | think | the | would | look | | |

15.3.2. Bolivia

| word 0 | word 1 | word 2 | word 3 | word 4 | word 5 | word 6 | word 7 | word 8 | word 9 | word 10 | word 11 | Label |
|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|------------|------------|-------|
|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|------------|------------|-------|

| | | | | | | | | | | | | |
|--------------------|------------|---------------------|--------------|-------------------|-------------------|--------------------|-------------|----------------|------------|-------------|--|--|
| natio nal | farm er | offic e | ever y | supp ort | com muni ty | opera tion | free | popul ation | help | | | farmer/fa rming support/ communi ty working/ communi ty help |
| popu latio n | show | regio n | activ ity | incre ase | diver sity | latin | amer ica | many | repor t | well | | populatio n/populat ion diversity/ populatio n analysis |
| day | time | may | publi c | new | espe cially | viole nce | like | one | many | | | crime/ violence |
| progr am | work | supp ort | scho ol | com muni ty | chan ge | need | many | focus | help | | | schooling / communi ty upliftmen t program mes/ bringing about change/ support for upliftmen t |
| one | state | infor mati on | agen cy | plan | ande an | offici al | large st | well | latin | amer ica | | |
| presi dent | area | trend | since | well | inco me | gove rnme nt | state | grou p | show | | | governan ce/ governm ent income/ presidenti al trend |

| | | | | | | | | | | | | |
|--------------|-----------------------|--------------------|--------------------|-----------------|---------------|---------------|-----------------------|------------|-----------------------|--------------|--|--|
| peopl e | indig enou s | peop le | indig enou s | milli on | term | incre ased | law | water | well | toget her | | indigeno us people law/ water in relation to indigeno us |
| resou rce | inter natio nal | proje ct | glob al | one | work ing | coca | impa ct | state | tax | | | tax generatio n/ coca economy/ internatio nal and global influence on economy |
| tax | devel opme nt | boliv ian | gove rnme nt | inco me | regio nal | see | gove rnme nt | numb er | inter natio nal | tren d | | tax/inco me for governm ent/ regional governm ent income |
| rate | amaz on | socia l | curre nt | instit ution | clim ate | home | econ omic | since | inclu ding | | | amazon/c limate effects/ economic |
| wom an | face | gove rnme nt | mora le | pove rty | despi te | chall enge | curre ntly | covid | total | | | gender/ poverty & challenge s/ covid challenge |
| level | acros s | mem ber | partn er | toda y | large st | day | inter natio nal | regio n | gove rnme nt | | | |
| local | justic e | prote ct | repor t | meas ure | finan cial | right | inter natio nal | today | econ omic | | | justice & rights/ financial measures |

| | | | | | | | | | | | | |
|-------------|-----------|------------|---------|------------|------------|--------------|----------|-------------|------------|-------------|------------|--|
| also | south | america | group | access | two | build | place | help | coca | partnership | | south american cooperation/ cocoa partnership |
| jeanine | anez | political | evo | moral | government | organization | way | make | provide | right | population | politics/ governance |
| around | impact | region | culture | together | may | working | support | government | change | | | regional culture/ work/ government support |
| food | life | growth | control | population | high | culture | member | community | government | | | culture/food/ culture & food & population |
| service | including | protection | partner | include | since | million | free | development | across | | | |
| salt | flat | salt | flat | specie | area | saline | volcanic | type | name | value | | geography/ volcanic/ slat |
| volcano | volcanic | chain | supply | strong | active | flow | impact | case | effect | | | supply chain/ volcano |
| range | andesian | water | specie | attitude | towards | area | northern | south | lineage | | | andes ecosystem/water |
| groundwater | latin | system | result | year | population | change | data | study | water | | | water & ground water/ water resources / effect of population |

| | | | | | | | | | | | | |
|------------|--------------|--------------|-------------------|----------------------|--------------------|--------------------|--------------|----------------------|---------------|--|--|---|
| | | | | | | | | | | | | n & water |
| foun d | resou rce | natur al | sout hern | distri butio n | also | depe nden ce | north | politi cal | econ omic | | | natural resource distributi on and dependen ce/ natural resources & economy & politics |
| cost | lithiu m | clim ate | diver sity | wetl and | meth od | regio n | speci e | phylo genet ic | mode l | | | lithium mining/ lithium effect on ecosyste m/ |
| polic y | resea rch | mobi lity | regio nal | also | year | study | wom an | socia l | meas ure | | | women social & policy |
| death | south | wate r | com pone nt | covi d | healt h | regio n | perio d | chan ge | part | | | covid & healthcar e |
| the | alrea dy | they | vacci ne | day | one | put | milli on | coup | case | | | vaccine issues |
| unite d | dema nd | acco unt | legal | repu blic | luxe mbo urg | belgi um | respo nse | germ any | lithu ania | | | tax & accountin g legal issues/ luxembo urg, belgium, lithuania, and germany influence |
| woul d | much | like | play | right | doe | also | goal | better | game | | | |

| | | | | | | | | | | | | |
|-----------|-----------|---------|-------|----------|--------|----------|---------|------------|----------|---------|--|------------------------------------|
| evo | america | win | the | arce | cup | paz | latin | morales | american | | | evo racing/motorsports |
| bolivia | people | country | want | know | like | see | many | say | coup | | | political coup |
| bolivia | time | year | think | face | peru | going | the | hope | end | | | peru and bolivia |
| venezuela | argentina | peru | chile | paraguay | brazil | colombia | ecuador | cuba | uruguay | | | south american countries influence |
| leave | santa | cruz | enter | top | santa | cruz | thanks | government | vote | concert | | |

15.3.3. Chile

| word0 | word1 | word2 | word3 | word4 | word5 | word6 | word7 | word8 | word9 | word10 | word11 | Label |
|--------|-------------|---------------|--------|-------|------------|----------|--------|----------|-----------|--------|--------|--|
| health | contact | activity | city | life | work | product | among | service | become | | | |
| people | local | environmental | leader | among | government | service | one | congress | education | | | government/politics/people and government |
| trade | development | education | growth | page | first | business | market | access | covid | | | trade & economic development/covid and economy |

| | | | | | | | | | | | | |
|--------------------|--------------|--------------|---------------------|-------------|--------------------|--------------|----------------|--------------------|-----------------------|--------------------|-----------|--|
| latest | santia go | issue | invest ment | right | inter est | year | get | econ omy | produ ct | | | investm ent/ capital region econom y |
| new | price | first | variet y | regi on | date | acce ss | busin ess | expe rienc e | produ ct | | | |
| help | area | south | ameri ca | part y | way | live | past | high | life | free | | |
| may | santia go | chile | work | find | latin | ame rica | date | latest | set | price | tra de | latina america n trade |
| right | end | south | infor matio n | date | one | regi on | city | may | enviro nment al | | | environ mental |
| year | onlin e | millio n | help | covi d | two | high | exper ience | area | amon g | | | covid related |
| man y | natio nal | south ern | office | beco me | sout h | ame rica | covid | wate r | peopl e | two | | water and south america |
| mark et | repor t | use | time | toda y | regio n | full | tax | onlin e | trade | | | trade and market related/ tax related |
| supp ort | latin | ameri ca | covid | also | tech nolo gy | mak e | histo ry | inves tmen t | peopl e | gover nmen t | | investm ent/ technolo gy |
| meas ure | see | high | econo my | may | educ ation | right | servi ce | year | trade | | | educatio n/econo my |
| one | intere st | centra l | comp any | inclu de | may | supp ort | servi ce | latin | ameri ca | south | | |
| expe rienc e | water | get | desert | addr ess | inclu de | santi ago | set | work | home | | | water/ca pital region/ |

| | | | | | | | | | | | | |
|--------------------|--------------|-----------------|---------------------|---------------|-------------|---------------------|----------------|---------------------|---------------|--------------------|--|---|
| | | | | | | | | | | | | water related |
| servi ce | home | two | trade | polic y | prod uct | lead er | help | live | memb er | | | trade policy |
| best | travel | destin ation | find | city | full | may | risk | prod uct | conta ct | | | tourism |
| need | gabriel | boric | risk | presi dent | socia l | cong ress | plan | mak e | tax | gover nmen t | | tax & political problem s/ presiden tial problem s |
| prod uct | busin ess | every | chile | one | acce ss | milli on | polic y | see | office | set | | business |
| mem ber | take | econo mic | infor matio n | end | covid | lead er | new | cong ress | conta ct | | | covid and econom y |
| gove rnme nt | free | econo my | set | year | trade | desti nati on | may | time | santia go | | | trade develop ment/ economi c policy |
| healt h | covid | child | count ry | pand emic | year | fami ly | food | asso ciati on | risk | | | covid related issues/p andemic related issues |
| popu latio n | patie nt | treatm ent | group | soil | samp le | dise ase | contr ol | risk | strain | | | healthca re/ disease control & risk |
| wom an | plant | gende r | femal e | map uche | high er | usin g | body | diffe renc e | comm unity | | | gender and women |
| stude nt | schoo l | teache r | educa tion | phys ical | care | anal ysis | perce ption | univ ersit y | practi ce | | | educatio n |

| | | | | | | | | | | | | |
|--------------|----------------------|----------------|-----------------------|--------------------|---------------|-------------------|---------------------|---------------------|----------------|---------------------|--|---|
| coun try | latin | progr am | resear ch | univ ersit y | amer ican | latin | amer ican | educ ation | analys is | devel opme nt | | higher educatio n |
| socia l | polic y | politic al | analy sis | publ ic | chile an | wor k | appr oach | proc ess | based | | | political analysis |
| syste m | energ y | model | data | cost | emis sion | diffe rent | impa ct | usin g | based | | | cost of energy/ emissio n |
| mod el | data | earthq uake | using | effec t | firm | seis mic | used | spati al | time | | | geograp hic/ earthqua ke |
| urba n | area | city | conce ntrati on | sour ce | elem ent | poll utio n | comp ositio n | anal ysis | sampl e | | | urban pollutio n |
| speci e | distri butio n | south | divers ity | foun d | genu s | sout hern | fish | food | analys is | | | fish/ food related |
| wate r | chan ge | climat e | forest | area | cond ition | surf ace | regio n | temp eratu re | effect | | | climate change |
| would | like | come | chilea n | year | coun try | best | make | thing | what | | | travel to chile related |
| peop le | also | witho ut | coun try | new | well | say | supp ort | nothi ng | vacci ne | | | |
| santi ago | get | put | photo | com mun ist | santi ago | chile | publi shed | live | first | win | | capital region politics/ commun ist |
| time | and | see | good | look | goin g | cont inue | never | chile ans | univer sity | | | |
| chile | today | love | whew | anot her | whe w | chile | dont | kno w | see | got | | |
| want | know | presid ent | every thing | you | take | right | alrea dy | man y | doe | | | |
| the | left | day | argen tina | vote | colo mbia | bette r | one | peru | brazil | | | |

15.3.4. Paraguay

| word0 | word1 | word2 | word3 | word4 | word5 | word6 | word7 | word8 | word9 | word10 | word11 | Label |
|---------|----------|-----------|---------------|------------|--------|---------|----------|----------|------------|--------|---------|---|
| member | two | main | significant | response | threat | south | america | despite | key | sector | | |
| global | official | public | security | department | crisis | effort | good | national | get | | | national security/ crime/ official response |
| show | month | day | high | life | based | partner | activity | help | corruption | | | corruption related |
| include | know | political | impact | power | well | local | state | public | partner | | | political/ public partnership/ state vs central/ political impact |
| social | home | today | covid | national | effort | land | million | people | corruption | | | corruption/ covid/ public affected |
| america | latin | america | participation | improve | find | work | local | south | america | make | despite | work availability/ job availability/ improving work opportunity / america |

| | | | | | | | | | | | | |
|---------------------|--------------------|----------------------|-------------------|---------------------|----------------|--------------|-----------------------|--------------------|-----------------|------------------|--|---|
| | | | | | | | | | | | | and latina america participatio n |
| repo rt | cur rent ly | law | part ner | supp ort | rank | bas ed | ma ke | help | eco no my | | | law support and effect on economy |
| peo ple | pop ulat ion | mad e | area | city | me mbe r | rate | war | deca de | liv e | | | effects of long war on population and lives |
| proj ect | set | part icul arly | rem ains | deve lopm ent | acce ss | lev el | co mm unit y | inco me | are a | | | access to developmen t/ developmen t of areas for community and income upliftment |
| info rmat ion | cor rup tion | help | wor k | citiz en | num ber | unit ed | stat e | oper atio n | nat ional | f i n d | | corruption/ information and help on corruption/ |
| way | sou rce | mar ket | sect or | trade | like | acti vity | pan de mic | para guay an | glo bal | | | effect of global and pandemic/ |
| land | wor kin g | agri cult ure | com mun ity | amo ng | futu re | wel l | poli tica l | nati onal | me mb er | | | agricultural policy/ land and agriculture working/ agricultural policy |
| asun cion | nee d | larg est | trav el | impo rtant | cent er | get | ma y | braz il | ma ke | | | need for infrastructu re/ important to develop capital region/ |

| | | | | | | | | | | | |
|------------|---------|-----------|----------|------------|-------------|----------|-----------|---------|----------|----------|---|
| regional | economy | president | around | however | see | national | people | largest | south | american | presidential actions/ regional economy/ south american |
| export | product | different | good | according | data | million | increase | every | system | | export/ trade/ |
| production | provide | national | million | community | like | improve | increase | main | public | | production and trade/ improve trade/ community and public role in trade |
| growth | term | since | trade | income | brazil | pandemic | make | largest | economy | | trade relations with brazil/ effect of pandemic economically |
| united | state | office | business | activity | financial | system | economy | with in | company | addition | financial system/ trade relations with the US |
| new | state | resource | like | pandemic | information | future | citizen | impact | national | | resources for pandemic/ future impact of pandemic on people |
| paraguyan | family | together | child | especially | time | life | community | large | much | | social and population impact |

| | | | | | | | | | | | | |
|-------------|------------------|-------------------|-------------|---------------|-------------------|-------------------|------------------|--------------|-----------------------|---------------------------------|--|---|
| kno w | wa nt | play | worl d | selec tion | eve n | wor ld | wel l | anot her | pla yer | | | football or other play |
| love | goo d | mak e | best | thing | pan ama | bea utif ul | nati ona l | grea t | gu ate ma la | | | people sentiment for the country |
| first | par agu ay | com e | vacc ine | presi dent | club | tell | ther e | thou sand | poi nt | | | covid vaccine encouragem ent |
| vote | bor der | ciud ad | para na | este | ciud ad | este | tripl e | diari o | alt o | p r i n t e d | | border and cities issues |
| cou ntry | like | goal | sout h | what | ame rica | am eric an | loo k | team | ma tch | | | USA/ teaming up with USA |
| they | tim e | nev er | with out | give | tea m | free | gav e | went | foo tba ll | | | football |
| also | wo uld | gam e | live | mad e | guar ani | lan d | spai n | italy | lib ert ad | | | regional demographi cs and history |
| alre ady | thin k | asu ncio n | new s | man y | wor k | rive r | nee d | new s | flig ht | | | river/ capital regiona |
| ame rica | goi ng | case | year | take | coul d | cov id | last | still | par ty | | | covid effect on USA and COVID's impact on paraguay |
| peo ple | this | arge ntin e | lost | conti nue | noth ing | tha nks | tues day | june | sup por t | | | |
| heal th | cou ntr y | rate | latin | follo wing | diff eren t | spe cie | stud y | revi ew | co vid | | | health/ covid effects/ |

| | | | | | | | | | | | | |
|---------------|------------|--------------|-------------|----------|----------|------------|-----------|-------------|---------------|-------|--|--|
| south hern | also | distribution | specific | american | threat | showed | potential | addition | distinct | | | |
| water | system | model | temperature | study | addition | region | data | sample | precipitation | | | environment/ water resource monitoring |
| area | risk | water | social | study | part | affected | scenario | temperature | impact | | | effects of water resource and associated risk |
| group | risk | source | among | paper | country | population | term | creative | common | issue | | |
| country | south | number | component | analysis | data | change | latin | american | control | | | research and analysis |
| andes | cordillera | andean | evolution | main | part | growth | change | different | associated | | | changes to the andes range |
| social | area | risk | scenario | change | process | different | current | based | show | | | social changes and change process |

15.3.5. Peru

| word 0 | word 1 | word 2 | word 3 | word 4 | word 5 | word 6 | word 7 | word 8 | word 9 | word 10 | Label |
|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|------------|------------------------------------|
| lima | food | spread | fight | right | major | support | leader | national | latin | american | political leadership change/ |

| | | | | | | | | | | | |
|---------------------|-----------------|--------------|----------------|--------------|--------------|-----------------|---------------------|----------------|--------------|------------|---|
| | | | | | | | | | | | fight for change/ food related |
| politic al | due | state | report | with out | suppo rt | want | infor matio n | find | confli ct | | political conflict/ politics/ informati on and transpare ncy |
| castill o | com pan y | group | projec t | two | policy | meet | first | marke t | high | | president' s influence on economy/ market/ projects |
| infor matio n | prov ide | severa l | amon g | mem ber | syste m | lead | hour | marke t | doe | | |
| water | milli on | know | invest ment | stron g | additi on | dema nd | high | vulner able | amp | | investme nt in water/ need for investme nt in water resources |
| day | mac hu | picch u | advent ure | guid e | travel | destin ation | cultur al | see | sacred | valle y | tourism |
| partne r | smal l | officia l | urban | alon g | best | natur e | great | chang e | way | | maintena nce of nature/ nature preservati on/ public private partnershi p |
| united | state | learn | presid ent | econ omic | ameri ca | conti nue | oppor tunity | region al | open | offic e | regional and american |

| | | | | | | | | | | | |
|------------------|---------------------|-----------------|-----------------|----------------|-------------------------|---------------|------------------|-----------------|-----------------------|----------------|---|
| | | | | | | | | | | | economic opportuni- ties |
| new | take | cusco | visit | book | touris- m | offer | every | travel | used | | tourism |
| develo- pment | soci- al | spanis- h | may | site | office | fund | partn- ership | today | peopl- e | | social developm- ent through funding/p- artnership |
| health | top | set | level | glob- al | regist- ered | data | back | using | across | | healthcar- e/ health/ data on health records |
| peruvi- an | use | many | city | ande- s | home | ancie- nt | much | nation- al | peopl- e | | historical |
| get | wor- king | since | march | econ- omic | intern- ationa- l | covid | center | comm- itted | suppo- rt | | economy/ economic developm- ent/ covid support/ |
| woma- n | peo- ple | life | popul- ation | follo- wing | area | today | right | inequa- lity | living | | gender inequality / populatio- ns related issues |
| huma- n | right | includ- ing | progra- m | num- ber | also | need | work | since | justice | impa- ct | human rights/ crime/ justice |
| alread- y | kno- w | gover- nment | turkey | corr- upt | everyt- hing | conti- nue | peopl- e | want | right | | corruptio- n |
| castill- o | pres- iden- t | pedro | pedro | casti- llo | fujim- ori | keiko | suppo- rt | presid- ent | leaf | peruv- ians | presidents present and past |
| vote | wan- t | debate | candid- ate | well | presid- ential | video | better | seems | iheart award- s | | voting related |

| | | | | | | | | | | | |
|---------------|-----------|----------------|------------------|--------------|---------------|--------------------|----------------------|-----------------|---------------|--------------------|---|
| people | left | make | witho ut | noth ing | look | work | many | game | thanks | | people migration |
| time | lima | they | going | that | electi on | probl em | under stand | since | world | | |
| countr y | year | peru | give | good | take | still | last | would | team | | |
| best | thin k | army | butter | vote | kcame xico | fando m | thing | today | vote | butte r | |
| this | love | must | need | acco unt | goal | gover nmen t | legal | thanks | dema nd | | governme nt/ legal |
| live | wha t | world | peruvi an | com e | first | name | sham e | hahah a | leave | | negative peruvian pride |
| crimin al | libre | party | hope | cong ress | never | vacan cy | made | debate | anythi ng | | corrupt politics/ criminal activities/ need for debates/ need for change |
| comm unity | wate r | bird | countr y | resul t | area | chang e | agric ultura l | consu mer | divers ity | | water and agricultur e/ water related problems |
| countr y | city | profil e | supply | stud y | analys is | coast al | data | variab ility | death | | geographi c and demograp hic analysis |
| specie | stud y | popul ation | distrib ution | usin g | region | area | group | chilea n | risk | | demograp hics analysis |
| water | slab | surfac e | region | uplif t | wedge | data | water | resour ce | resour ce | subd uctio n | geographi c analysis and concerns |

| | | | | | | | | | | | |
|-------------|--------------|------------------|---------------------|--------------|-----------------------|-------------|--------------|-----------------|--------------|------|---|
| countr y | latin | ameri can | consu mptio n | fishe ry | intake | study | risk | health | author | | problems with fishing industry |
| countr y | latin | model | study | latin | ameri can | price | analy sis | develo pment | ameri can | rate | |
| countr y | regi onal | resear ch | ameri can | reso urce | intern ationa l | carrie d | latin | numb er | econo mic | | regional and latin american economy |
| area | syst em | conser vation | range | usin g | study | andea n | clima te | chang e | specie | | climate change, andes change |
| plate | nazc a | based | zone | crust al | oceani c | polic y | ridge | seismi c | south | | geographi cal analysis and concerns |

15.3.6. Uruguay

| word 0 | word1 | word 2 | word 3 | word 4 | word5 | word 6 | word 7 | word 8 | word 9 | word10 | word11 | Label |
|----------------|-----------|---------------|------------|---------------------|--------------|-----------------------|--------------|------------|-----------------------|--------------------|--------|--|
| popul ation | latin | ameri ca | data | infor matio n | see | intern ation al | europ ean | syste m | also | busin ess | | |
| regio n | crim e | inclu ding | globa l | establ ished | econ omic | latin | ameri ca | social | intern ation al | gove rnme nt | | context of crime: econo mic/glo bal |

| | | | | | | | | | | | | |
|-----------------------|--------------------|--------------|---------------|--------------|---------------------|---------------|-----------------------|---------------------|---------------------|------------|--|---|
| intern ation al | socia l | locati on | finan cial | seek | trave l | place | natio nal | urugu ayan | help | | | tourism / travel |
| spani sh | way | stude nt | also | schoo l | park | see | natio n | work | face | | | schooli ng and work |
| meas ure | gove rnme nt | high | area | busin ess | esta blish ed | see | regio n | howe ver | devel opme nt | | | regiona l develo pment/ busines s |
| medi um | gene ral | provi de | part | natio nal | life | regio n | also | europ ean | inclu ding | | | |
| servi ce | value | netw ork | syste m | partn er | mar ket | show | data | busin ess | since | | | market/ busines s networ k/ market system |
| argen tina | mem ber | every | large st | work | sho w | urugu ayan | gover nmen t | devel opme nt | busin ess | | | argenti na & urugua y/ govern ment related develo pments & busines s |
| gover nmen t | cultu ral | anoth er | locati on | place | first | urugu ayan | intern ation al | stude nt | spani sh | | | internat ion student s/ culture |
| howe ver | euro pean | since | south | ameri ca | part y | also | econ omic | gover nmen t | finan cial | syste m | | financi al system/ system/ |

| | | | | | | | | | | | | |
|---------------|--------------|-----------------------|----------------|---------------------|-------------------|--------------|-----------------------|----------------|----------------|--------------------|-----|---|
| presi dent | first | econ omic | make | gover nmen t | mar ket | natio n | south | ameri ca | latin | amer ica | see | preside nt/ south americ an market |
| help | open | intern ation al | work | infor matio n | mak e | latin | ameri ca | urugu ayan | high | natio nal | | global/ internat ional busines s |
| politi cal | natio nal | devel opme nt | based | right | face | visit | intern ation al | syste m | show | | | |
| urugu ayan | may | covid | life | stude nt | open | place | south | ameri ca | econ omic | gove rnme nt | | covid/ econo mic effect/ affecte d student s |
| healt h | man y | travel | conta ct | effect | inclu de | part | infor matio n | natio nal | park | | | healthc are/ travel/ parks |
| kang aroo | like | also | chan ge | playi ng | fight | milli on | fact | inhab itant | know | | | |
| ameri ca | playe r | great | south | select ion | som ethin g | ameri can | final | first | seem s | | | |
| alrea dy | team | best | vacci ne | goal | leav e | count ry | must | urugu ay | vacci nated | | | vaccina tions |
| peopl e | worl d | count ry | every thing | mont evid o | left | this | right | party | next | | | captial region/ politics |
| come | play | take | ameri ca | when | spai n | costa | latin | pana ma | back | | | sports context |
| going | live | want | think | what | mak e | today | know | well | thing | | | |

| | | | | | | | | | | | | |
|------------|------------|------------|----------|-------------|------------|--------------|--------------|------------|-----------|----------|-----------|--------------------------|
| year | good | love | give | like | continue | argentine | life | people | nothing | | | people and culture |
| would | game | time | match | made | face | point | fire | tell | with | | | football |
| vote | government | look | little | president | photo | need | show | population | friend | | | president campaign/ vote |
| world | million | better | single | victory | every | billion | australia | million | million | victory | australia | |
| case | they | work | covid | there | death | from | coronavirus | last | people | | | covid |
| south | soil | water | food | region | part | data | southern | product | specie | | | geography & species |
| south | american | focused | related | research | process | particularly | latin | american | latin | southern | | |
| specie | south | using | model | study | method | analyzed | distribution | taxonomic | genetic | | | species research |
| latin | analysis | latin | american | american | inequality | activity | older | need | food | adult | | inequality |
| result | latin | analysis | four | chilean | recognized | state | special | main | including | | | |
| study | springer | show | research | present | role | nature | urban | result | lack | | | nature |
| group | factor | case | level | among | process | research | adult | regarding | care | | | adult care |
| hypothesis | paper | importance | period | development | test | finding | used | increasing | group | | | |
| health | social | older | labor | nature | exclusive | adult | rate | people | provide | | | social & labour analysis |

| | | | | | | | | | | | | |
|------------|------|--------------|----------------------|-------|-------|-------|-------|-------|---------------------|--|--|----------------------------------|
| polic y | area | resea rch | conse rvatio n | south | latin | world | study | urban | devel opme nt | | | conser vation researc h |
|------------|------|--------------|----------------------|-------|-------|-------|-------|-------|---------------------|--|--|----------------------------------|

15.4. Interview protocol & guide

Note: The below questions are a guide and thus should not be treated as exhaustive. Modify, add, or delete as required during the interview.

Exchange pleasantries.

Ask permission for recording the interview.

“Just to let you know that everything you say here today will be anonymous and confidential. It is being recorded and will be saved on the University of Strathclyde’s OneDrive storage. Only my supervisors and I will have access to it. Please feel free to be as honest as possible. Nothing will be attributed to you as an individual or to you as a business. You do not have to answer any of the questions, and you’re not obliged to stay, you can leave at any time. Do you agree and consent and I can go ahead please?”

Begin the interview.

How did this project come to be? why was it decided that a scenario planning project was needed?

How were you involved in the project and how was your experience?

- Let me take you back in time to the beginning of the project, where we started collecting and analysing some of the sources of information such as websites, papers, and articles.
- How was your experience during data collection?
- Tell me some of the challenges that you faced during data collection.

Let me show you my research framework; with respect to this how do you think the filters would have affected the project?

Surveillance filter: The surveillance filter defines the field of observation. The narrower the focus, higher the chance of missing the weak signals and too broad the focus higher the chance of missing the main issue. This makes it difficult to get the right balance.

- How do you think surveillance filter could have affected the information that was collected?
- How can we overcome this?

Mentality filter: The mentality filter defines the tendency of managers to be in denial or even reject novel information that does not fit into their experience or reference points

- How do you think mentality filter could have affected the information that was collected and synthesised?
- How can we overcome this?

Power filter: This is the politics that affects the information processing. The person(s) in power may reject the novel information in order to maintain their current position of power and relevance. (Ansoff, 1990).

Open the workbook and the drivers identified

- What do you think – surveillance filter could affect during the analysis of the workbook itself
- What do you think – mentality filter could affect during the analysis of the workbook itself

The below questions are for people involved in the driver identification (Swiss and MBA team). The questions cover mentality filter, surveillance filter and power filter.

- How did you receive the workbook?
- How did you go about selecting the drivers?
- What were the difficulties/challenges that you faced? – surveillance filter, mentality filter
- Did you experience any power filters during the project? power filter

Show the machine learning output

Now what if we use machine learning to identify the drivers instead of generate workbook? What do you think about this? Prompt – surveillance filter, mentality filter etc.

Anything else you would like to add?

Thank you so much for participating.

End recording.

15.5. Dean's approval for SBS – 2035

Subject: Re: School Scenarios
Date: Tuesday, 6 April 2021 at 20:11:18 British Summer Time
From: David Hillier
To: Peter McKiernan
CC: Vivek Venugopal
Attachments: image001.jpg, image002.png, image003.png, image004.png

Hi, Peter, and hi, Vivek.

I'm more than happy for you to use the scenarios. RE: Interview. If we can get it in the diary, it's not a problem.

Best of luck!

Kind Regards,

David

Professor David Hillier PhD BSc (Hons.) FRSA
Associate Principal and Executive Dean (Strathclyde Business School)
University of Strathclyde
199 Cathedral Street
Glasgow, G4 0QU

Tel: +44 141 548 5844
Email: David.hillier@strath.ac.uk

www.strath.ac.uk/business

Strathclyde Business School is [triple accredited](#)



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UK UNIVERSITY
OF THE YEAR
FOR A SECOND TIME



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From: Peter McKiernan <peter.mckiernan@strath.ac.uk>
Date: Tuesday, 6 April 2021 at 14:58
To: David Hillier <david.hillier@strath.ac.uk>
Cc: Vivek Venugopal <vivek.venugopal@strath.ac.uk>
Subject: School Scenarios

Dear David,

I trust all is well.

This email introduces Vivek Venugopal, a doctoral scholar in SBS supervised by Aylin Ates and me.

15.6. Letter to EIBE student requesting access

***** Begin letter *****

Dear <student name>,

Hope you are enjoying your MBA till now!

As you must have experienced, all the courses are very relevant to the present business environment. This is possible as courses are continually updated and improved based on cutting edge research. EIBE is one such course and we are trying to explore how technologies such as machine learning/AI could be included in the scenario planning process. **For this we need your support!** Your participation will help us to further improving the course and to deliver a state-of-the-art product.

How can you support?

1. We need your permission to access your miro boards from the EIBE course. We will look at the drivers on the boards that your group generated in iteration 2 and compare these with the output of a machine learning model. If you are happy to give this permission, you do not have to do anything further. If you grant permission, we can send you a summary of our research results.
2. If possible, could you kindly add vivek.venugopal@strath.ac.uk as a collaborator on your miro board please. This would help us in accessing the drivers.
3. If you do not wish to give permission, please respond to this email by replying <Please do not access> before 22nd May 2022. Kindly mention your group, country you worked on, year, cohort, and the centre to which you belong please.

One more thing, **your opinion counts!** We would like your view on using machine learning for driver detection in scenario planning and, if possible, we would like to chat with you in a short zoom interview of about 15 minutes.

If you are happy to participate, kindly reply to this email by stating <Interested in participating for the interview> and please mention the group, year, country you worked on, cohort, and the centre to which you belong. We will then send you a calendar link where we can book a time that suits you. The interview will be conducted by the researcher (Vivek).

About Vivek (researcher): I am currently based in the Glasgow campus. I am originally from Bangalore, India. Before my transition into academia, I worked for about 10 years in SME plastic moulding sector. My wife is a software programmer, and we have two young sons who are constantly asking for getting pet Guinea pigs, which we have resisted till date, but slowly giving in! I am in the final stages of my PhD and hope to graduate this year along with you all. I am researching the role of ML/AI technologies for detecting drivers for scenario planning. Prof Peter McKiernan and Dr Aylin Ates are supervising this research. Getting access to your data is crucial for the completion of my PhD and I am hoping to get your support as a fellow Strathclyde. Thank you in advance.

Your participation is voluntary and all personal information will be anonymised. Your participation will not affect your grades in anyway. Nothing you say can be attributed back to you. All information will be stored securely on the University's OneDrive platform and will be accessible only by the researcher (Vivek) and the supervisors.

Thank you in advance and wishing you nothing but the best!

***** End letter *****

15.7. Survey questionnaire

Scenario planning Strathclyde Business School

Start of Block: Default Question Block

Q18 This survey forms the first part of the research. It will be followed by semi-structured interviews. The time taken to complete this survey is approximately 7 - 10 minutes.

Integration of machine learning and human centric methods would open the door to new ways of doing horizon scanning and scenario planning. For the findings to be of practical use, it is vital that all members of the original scenario planning team participate in all aspects of the research. By agreeing to participate in this survey we assume you are agreeable to be contacted for semi-structured interview and invitation to our workshop.

As a thank you for participating in all the activities, that is survey and semi-structured interview, you will get a £25 amazon voucher and you will be granted exclusive access to our webinar on machine learning for horizon scanning and scenario planning.

Thank you for taking your time to fill out this survey. Your input is of huge value to us.

Q31 Important information:

The information collected in this survey is confidential. All reference to individuals and organisations will be anonymised. Only the investigators will be able access to the data collected and the participants.

All information will be recorded and saved on the University of Strathclyde's secure online server. Data will be held for 10 years (as required as per the post-graduate research stipulations of the University of Strathclyde) after which, it will be destroyed.

Q16 What is this survey?

The aim of this research is to understand the effects of machine learning on the filters of weak signals and Horizon scanning. We will use the Strathclyde Business School 2035 scenario building project as the case study. You have been selected as you were originally involved in the project.

Page Break

Q32 Some background information

Horizon scanning: "Horizon scanning is the systematic examination of potential threats, opportunities and likely future developments. Horizon scanning may explore weak signals, as well as persistent problems or trends" (Miles, 2005).

Scenario planning: "Scenario planning (SP) is a collaborative process to envision alternative future environments, articulate their implications, test the logic of long-term plans, strategies, and policies and, ultimately, prepare for impending change, using plausible and consistent narratives about the future" (Rowe, Wright and Derbyshire, 2017).

Weak signals: Weak signals are "imprecise early indications about impending impactful events". More simply, "they are symptoms of changes to come" (Ansoff, 1990)

Page Break

Q29 Please enter your full name (First name, Last name). Kindly note: This information will only be used for the purpose of generating amazon vouchers, if you become eligible.

Q5 Please select the age group that you belong to

- ☐ 18-25 (1)
- ☐ 26-30 (2)
- ☐ 31-35 (3)
- ☐ 36-40 (4)
- ☐ 41-45 (5)
- ☐ 46-50 (6)
- ☐ 51-55 (7)
- ☐ 56-60 (8)
- ☐ 61-65 (9)
- ☐ 66-70 (10)
- ☐ 71 and above (11)

Q6 Please select the gender you associate yourself with

- ☐ Male (1)
 - ☐ Female (2)
 - ☐ Non-binary (3)
 - ☐ Prefer not to say (4)
-

Q9 Please select the number of years of work experience you have

- ☐ 0 (1)
 - ☐ 0-1 (2)
 - ☐ 1-3 (3)
 - ☐ 3-5 (4)
 - ☐ 5-7 (5)
 - ☐ 7-9 (8)
 - ☐ 9-11 (9)
 - ☐ 11 and above (11)
-

Q12 Where is your main area of work experience?

- ☐ Academia, research (1)
 - ☐ Academia, non research (2)
 - ☐ Professional (3)
 - ☐ Others (please specify) (4)
-

Q11 Which of the following best describes your position at work?

- ☐ Senior Executive (12)
 - ☐ Executive (4)
 - ☐ Junior Manager (5)
 - ☐ Senior Manager (6)
 - ☐ Research / Teaching Assistant (7)
 - ☐ Lecturer (8)
 - ☐ Senior Lecturer (9)
 - ☐ Professor (10)
 - ☐ Other (please specify) (11)
-

Q13 How would you rate your knowledge in strategic foresight?

- ☐ Expert in the field (1)
 - ☐ Advanced (2)
 - ☐ Average (3)
 - ☐ Novice (4)
 - ☐ No knowledge (5)
-

Q29 How would you rate your knowledge in scenario planning?

- ☐ Expert in the field (1)
 - ☐ Advanced (2)
 - ☐ Average (3)
 - ☐ Novice (4)
 - ☐ No knowledge (5)
-

Q28 How would you rate your knowledge in horizon scanning?

- ☐ Expert in the field (1)
 - ☐ Advanced (2)
 - ☐ Average (3)
 - ☐ Novice (4)
 - ☐ No knowledge (5)
-

Q14 Which of the stages of the scenario planning project were you involved in?
(Please select all that apply)

☐

Information gathering (1)

☐

Workbook update (2)

☐

Driver identification (3)

☐

Cross-impact matrix (4)

☐

Creating the scenario narrative (5)

☐

Final set of scenarios for strategic planning (6)

Page Break

Q10 Surveillance filter

It is difficult to get the right balance of methodology and analysis techniques for searching novel information for scenario development. If the techniques used are too myopic, there is a risk of missing the bigger picture; if the techniques are too broad there is a risk of overlooking any novel information.

A surveillance filter includes methodology and analysis techniques used in information acquisition.

Q23 To what extent do you agree with the following statements?

It is possible that the information gathered during the scenario planning project for the business school was affected by surveillance filter.

- ☐ Strongly agree (4)
 - ☐ Agree (5)
 - ☐ Neutral (6)
 - ☐ Disagree (7)
 - ☐ Strongly disagree (8)
-

Q35 To what extent do you agree with the following statements?

In turbulent environments, using extrapolation methods (example: forecasting) will filter out information on discontinuity.

- ☐ Strongly agree (1)
 - ☐ Agree (2)
 - ☐ Neutral (3)
 - ☐ Disagree (4)
 - ☐ Strongly disagree (5)
-

Q20 To what extent do you agree with the following statements?

Machines are better than humans in recognising patterns from vast amounts of data and thus, can strike the right balance and overcome the surveillance filter.

- ☐ Strongly agree (1)
 - ☐ Agree (2)
 - ☐ Neutral (3)
 - ☐ Disagree (4)
 - ☐ Strongly disagree (5)
-

Q24 **Mentality filter:**

The mentality filter is the tendency of managers to ignore novel information when it does not fit with their experience or reference points.

Q26 To what extent do you agree with the following statements?

"Managers, when observing the current market, pay attention to the features that have succeeded in disrupting their processes in the past".

- ☐ Strongly agree (1)
 - ☐ Agree (2)
 - ☐ Neutral (3)
 - ☐ Disagree (4)
 - ☐ Strongly disagree (5)
-

To what extent do you agree with the following statements?

"We observe our current market and pay attention to those features that have succeeded in disturbing our processes before".

- ☐ Strongly agree (1)
 - ☐ Agree (2)
 - ☐ Neutral (3)
 - ☐ Disagree (4)
 - ☐ Strongly disagree (5)
-

Q27 To what extent do you agree with the following statements?

"When people encounter an event whose occurrence is so implausible, they hesitate to report it fearing they will not be believed".

- ☐ Strongly agree (1)
 - ☐ Agree (2)
 - ☐ Neutral (3)
 - ☐ Disagree (4)
 - ☐ Strongly disagree (5)
-

Q28 To what extent do you agree with the following statements?

Mentality filter could have affected the information that was collected for the scenario planning project.

- ☐ Strongly agree (1)
 - ☐ Agree (2)
 - ☐ Neutral (3)
 - ☐ Disagree (4)
 - ☐ Strongly disagree (5)
-

Q34

To what extent do you agree with the following statements?

Machine learning can overcome mentality filter during horizon scanning

- ☐ Strongly agree (1)
 - ☐ Agree (2)
 - ☐ Neutral (3)
 - ☐ Disagree (4)
 - ☐ Strongly disagree (5)
-

Q32 Power filter:

Is the filter when novel information from middle managers gets rejected or ignored due to the power dynamics or position dynamics of the senior manager(s).

Q33 Have you encountered a situation within this project where the information you provided was rejected or ignored as a results of power filters?

- ☐ Yes (4)
 - ☐ No (5)
 - ☐ Not sure (6)
-

Page Break

Q31 To what extent do you agree with the following statements?

It is plausible that machine learning can overcome mentality and surveillance filters.

- ☐ Strongly agree (1)
- ☐ Agree (2)
- ☐ Neutral (3)
- ☐ Disagree (4)
- ☐ Strongly Disagree (5)

Page Break

Q32 Is there anything else that you would like to add that you feel would be useful to inform our study?

—

Q32 As explained in the introduction, this survey is the first part of our research, into the effects of machine learning on the filters of weak signals and horizon scanning and will be followed up by semi-structured interviews.

The integration of machine learning and human centric methods would open new ways of doing horizon scanning and scenario planning. For the findings to be of practical use, it is vital that all members of the original scenario planning team participate in all aspects. We will be contacting you shortly to arrange a suitable time for an interview.

Thank you again for your participation in our study.

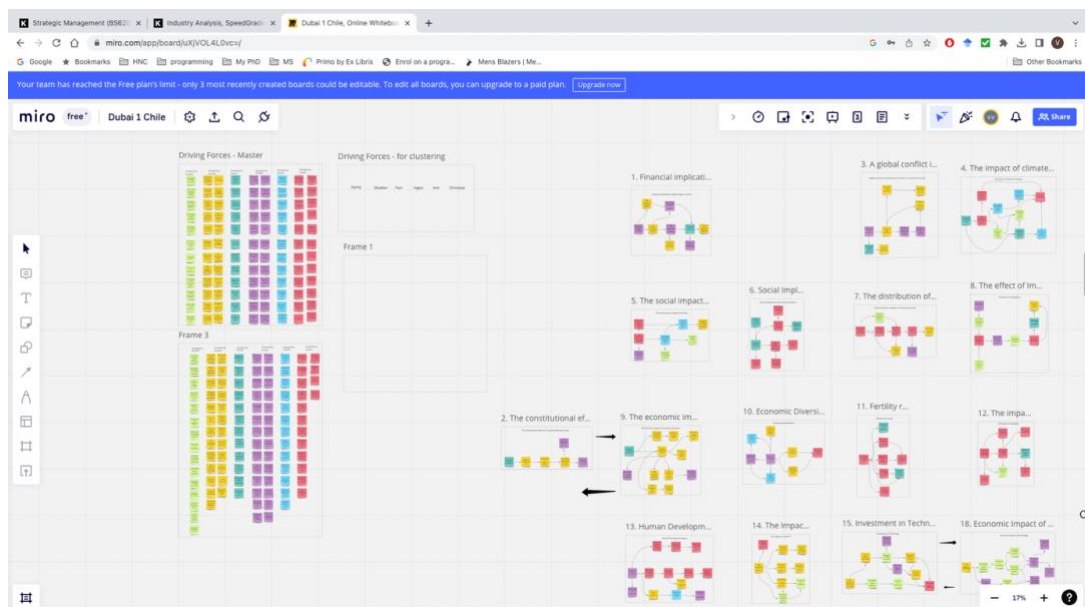
End of Block: Default Question Block

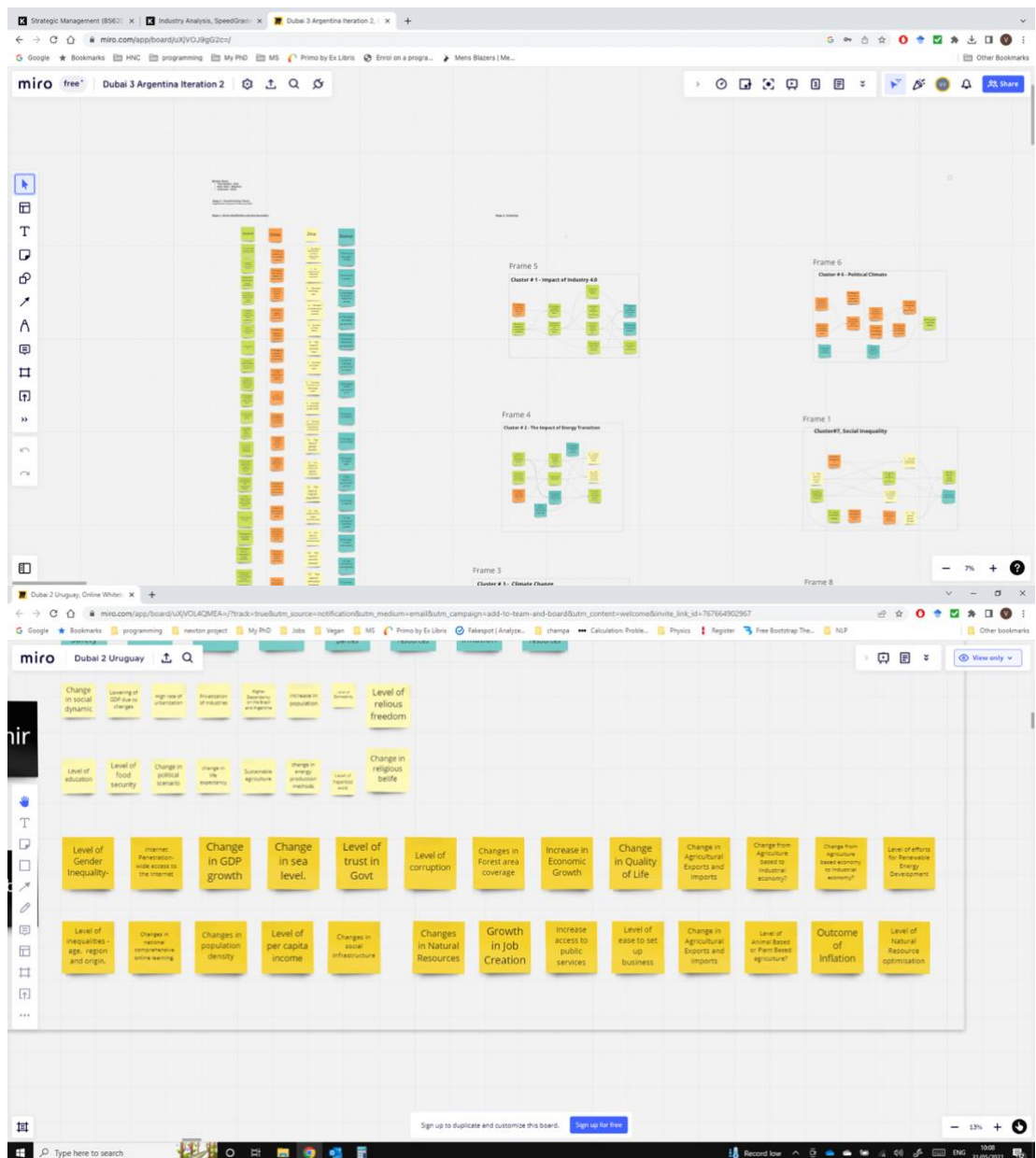
15.8. Driver downloaded and coded (EIBE) example

| Dubai 1 Chile Example | |
|--|----|
| The management of health insurance | 19 |
| The condition of Atacama Desert | 25 |
| The quality of healthcare | 19 |
| The impact of copper melter | |
| The level of gender inequality | 20 |
| The impact of an aging population on workforce | |
| The impact of de-privatizing water | 11 |
| Representation of female elected members | 20 |
| the change in the demand for lithium | |
| The effect of health insurance on taxation | 8 |
| Level of exports to China | |
| The impact of oil/natural gas prices | |
| The level of growth of FinTechs & ecommerce | 9 |
| The access to clean water | 11 |

| | |
|---|----|
| The level of male vs female education at University Level | 20 |
| The effect of trade restrictions | |
| Representation of indigenous elected members | 14 |
| the change in the price oil | |
| The effect of industrialization of water | 11 |
| The outcome of government debt | |
| The impact of natural disaster on tourist | 13 |
| Level of air pollution | 26 |

15.9. Example screen shots of EIBE student's scenario projects





You

what are the weak signals of change for argentina

Chat GPT

Weak signals of change are subtle indicators that can suggest shifts or trends in various aspects of a country such as politics, economics, society, technology, or the environment. For Argentina, some potential weak signals of change could include:

1. **Political Shifts**: Watch for emerging political movements, changes in voter sentiment, or shifts in political alliances that could indicate upcoming changes in government policies or priorities.
2. **Economic Indicators**: Keep an eye on fluctuations in key economic indicators such as inflation rates, unemployment rates, GDP growth, or changes in foreign investment patterns. Shifts in these indicators could signal changes in economic policies or market conditions.
3. **Social Movements**: Monitor grassroots movements, protests, or social media trends that reflect evolving social attitudes or concerns. This could include movements related to environmental activism, gender equality, indigenous rights, or other social issues.
4. **Technological Advances**: Look for emerging technologies or innovations that could disrupt traditional industries or create new economic opportunities. This could include developments in areas such as renewable energy, digital finance, or e-commerce.

5. ****Environmental Changes****: Pay attention to environmental indicators such as changes in weather patterns, natural disasters, or shifts in biodiversity. These could indicate broader environmental challenges or opportunities for conservation and sustainable development.
6. ****International Relations****: Track changes in Argentina's relationships with key international partners, including neighboring countries, major trading partners, or international organizations. Shifts in diplomatic priorities or trade agreements could have significant implications for Argentina's economy and foreign policy.
7. ****Demographic Trends****: Monitor demographic shifts such as changes in population growth rates, urbanization patterns, or aging populations. These trends could impact various aspects of society and the economy, including healthcare, infrastructure, and labor markets.
8. ****Cultural Expressions****: Pay attention to cultural trends, artistic expressions, or popular media that reflect evolving cultural norms or values. These could provide insights into shifts in Argentine society and identity.
9. ****Educational Developments****: Keep an eye on changes in education policies, enrollment rates, or educational outcomes. Improvements in education could drive innovation and economic growth, while challenges could indicate areas for intervention.
10. ****Healthcare Indicators****: Monitor healthcare outcomes, disease prevalence, or healthcare infrastructure developments. Changes in healthcare could impact public health, social welfare, and economic productivity.

These are just a few examples of weak signals of change that could provide insights into shifts or trends in Argentina. It's important to analyze these signals in context and consider multiple sources of information to develop a comprehensive understanding of the evolving landscape.



You

what are the weak signals of change for argentina 2035

ChatGPT

Predicting specific weak signals of change for a country like Argentina in 2035 involves a degree of uncertainty and speculation, but we can identify potential areas of transformation based on current trends and emerging issues. These signals could include:

1. **Renewable Energy Dominance**: Argentina has been making strides in renewable energy, particularly wind and solar power. Weak signals may indicate a significant shift towards renewable energy dominance by 2035, potentially surpassing fossil fuels as the primary energy source.
2. **Technological Innovation in Agriculture**: Argentina is a major player in global agriculture. Weak signals may suggest advancements in agricultural technology, such as precision farming, vertical farming, and genetic engineering, leading to increased productivity and sustainability in the sector.
3. **Urbanization and Smart Cities**: Buenos Aires and other major cities in Argentina may undergo significant urbanization and development by 2035. Weak signals could indicate the emergence of smart city initiatives, including

the integration of technology for efficient resource management, transportation, and governance.

4. ****Social and Political Shifts****: Weak signals may point towards significant social and political changes, potentially driven by demographic shifts, generational differences, or grassroots movements advocating for various causes such as climate action, social justice, or indigenous rights.

5. ****Climate Change Adaptation and Resilience****: Given Argentina's vulnerability to climate change impacts, weak signals may suggest a heightened focus on adaptation and resilience strategies across various sectors, including agriculture, infrastructure, and urban planning.

6. ****Emergence of New Industries****: Weak signals could indicate the rise of new industries and sectors in Argentina, driven by technological advancements, changing consumer preferences, or global market demands. This might include sectors such as biotechnology, sustainable tourism, or advanced manufacturing.

7. ****International Relations and Geopolitics****: Weak signals may hint at shifts in Argentina's foreign policy priorities, alliances, and economic partnerships by 2035, potentially influenced by global geopolitical dynamics, trade agreements, or regional integration efforts.

8. ****Healthcare and Biotechnology****: Weak signals may suggest advancements in healthcare and biotechnology, including personalized medicine, genomics, and medical technology innovations, contributing to improved healthcare outcomes and economic growth.

9. ****Cultural and Creative Industries****: Weak signals may indicate the continued growth and globalization of Argentina's cultural and creative

industries, including film, music, literature, and digital media, fostering cultural exchange and economic development.

10. ****Education and Skills Development****: Weak signals may suggest a transformation in Argentina's education system to meet the demands of the future workforce, including a greater emphasis on STEM education, digital literacy, and lifelong learning opportunities.

These weak signals represent potential areas of change and development for Argentina in the coming years, but their realization will depend on various factors, including policy decisions, societal dynamics, technological advancements, and global trends.



You

what are the weak signals of change for Brazil

ChatGPT

Weak signals of change for Brazil could encompass various aspects of the country's political, economic, social, technological, environmental, and cultural landscape. Here are some potential weak signals of change for Brazil:

1. ****Political Dynamics****: Observing shifts in political alliances, emerging political movements, or changes in public discourse can provide insights into potential changes in government policies, elections, or governance structures.

2. **Economic Indicators**: Monitoring fluctuations in economic indicators such as GDP growth, inflation rates, unemployment rates, foreign investment flows, and fiscal policies can signal changes in economic conditions, market sentiments, or policy directions.
3. **Social Movements**: Paying attention to grassroots movements, protests, or social media trends related to issues such as inequality, land rights, racial justice, LGBTQ+ rights, or environmental conservation can highlight evolving social attitudes and concerns.
4. **Technological Innovations**: Tracking advancements in technology sectors such as renewable energy, fintech, biotechnology, or artificial intelligence can indicate potential areas of economic growth, innovation, or disruption.
5. **Environmental Changes**: Monitoring environmental indicators such as deforestation rates, biodiversity loss, pollution levels, or climate-related events can reveal challenges or opportunities for environmental conservation, sustainable development, or climate adaptation.
6. **International Relations**: Analyzing Brazil's relationships with key international partners, participation in regional organizations, or diplomatic initiatives can shed light on the country's foreign policy priorities, trade dynamics, or geopolitical alignments.
7. **Demographic Trends**: Studying demographic shifts such as population growth rates, urbanization patterns, aging populations, or migration trends can inform policies related to healthcare, education, urban planning, and social welfare.

8. **Cultural Expressions**: Exploring cultural trends, artistic movements, or popular media can provide insights into evolving cultural identities, social norms, or expressions of collective values.

9. **Educational Developments**: Assessing changes in education policies, literacy rates, enrollment levels, or educational outcomes can signal improvements or challenges in human capital development and workforce readiness.

10. **Healthcare Indicators**: Monitoring healthcare access, disease prevalence, vaccination rates, healthcare infrastructure, or public health policies can indicate strengths and weaknesses in the healthcare system and potential areas for intervention.

These weak signals of change can serve as indicators of broader trends or shifts in Brazil's socioeconomic and political landscape. Analyzing these signals in conjunction with each other and considering historical contexts can provide a more comprehensive understanding of potential future trajectories for the country.



You

what are the weak signals of change for Brazil 2035

Predicting weak signals of change for Brazil in 2035 involves considering various factors such as economic, social, political, and environmental trends. While speculative, here are some potential weak signals for Brazil in 2035:

1. ****Renewable Energy Dominance****: Weak signals may suggest a significant increase in renewable energy production and adoption, with Brazil potentially becoming a global leader in renewable energy sources such as solar, wind, and hydroelectric power.
2. ****Technological Innovation Hub****: Weak signals could indicate the emergence of Brazil as a prominent hub for technological innovation and entrepreneurship, driven by investments in research and development, digital infrastructure, and supportive government policies.
3. ****Sustainable Development Initiatives****: Weak signals may point to a growing emphasis on sustainable development practices, including efforts to combat deforestation, promote sustainable agriculture, and protect biodiversity in the Amazon rainforest and other critical ecosystems.
4. ****Urbanization and Smart Cities****: Weak signals might suggest the rapid urbanization of Brazilian cities and the adoption of smart city technologies to address urban challenges such as transportation congestion, pollution, and public service delivery.
5. ****Social Inclusion and Equity****: Weak signals could indicate efforts to address social inequality and promote inclusive growth through policies aimed at improving access to education, healthcare, housing, and economic opportunities for marginalized communities.

6. **Geopolitical Shifts**: Weak signals may hint at changes in Brazil's geopolitical alignments and international relations, including potential shifts in trade partnerships, diplomatic alliances, and regional integration efforts.
7. **Healthcare Innovation**: Weak signals might suggest advancements in healthcare technology, medical research, and public health initiatives aimed at improving healthcare access, affordability, and quality of care for all Brazilians.
8. **Digital Transformation**: Weak signals could indicate the continued expansion of digital technologies and online services across various sectors of the Brazilian economy, including e-commerce, fintech, telemedicine, and remote work.
9. **Cultural and Creative Industries**: Weak signals may point to the continued growth and globalization of Brazil's cultural and creative industries, including film, music, literature, and digital media, contributing to cultural exchange and economic development.
10. **Climate Resilience Strategies**: Weak signals might suggest increased efforts to enhance climate resilience and adaptation, including investments in infrastructure, disaster preparedness, and community-based resilience programs to address the impacts of climate change.

These weak signals represent potential areas of change and development for Brazil in 2035, but their realization will depend on various factors such as policy decisions, societal dynamics, technological advancements, and global trends.

15.11. Interview protocol – expert interviews

Expert interview – Interview protocol

1. Exchange pleasantries.

2. Ask permission for recording the interview.

This is to let you know that everything you say here today will be anonymous and confidential. It is being recorded and will be saved on the University of Strathclyde's OneDrive storage. Only my supervisors and I will have access to it. Please feel free to be as honest as possible. Nothing will be attributed to you as an individual or to you as a business. Do you agree and consent and I can go ahead please?

3. Begin the interview.

| Interview Qs |
|---|
| Considering that AIs are becoming more and more embedded in our daily lives; |
| Have you used AI such as ChatGPT for identifying weak signals, trends, or drivers? If yes, please can you tell me more about the project? |
| What is your opinion on using AIs for scanning weak signals and drivers? |
| What do you think are the pros of using AI for detecting weak signals and drivers of change? |
| # <i>Following up with the previous question;</i> What about the cons of using AI? |
| How do you think AIs will affect the process by which humans process the information to drivers? |
| How do you think AI would affect the scanning process that we do whilst searching for drivers of change and weak signals? |
| How will the output or data from AI affect the of weak signals and driver detection? |
| How do you think the developments in AI will influence the current way of identifying drivers of change and weak signals. |

4. Thank the participant and conclude.

NOTE: This is not a structured interview. The interview will be semi-structured in nature and the researcher may amend and exclude questions depending on the circumstances.

15.12. ML output shown to participants in case 1, 2

| To pic | Machine learning top 10 words for the topic | | | | | | | | | | Label assigned manually |
|----------|---|-------------|-------------|------------|--------------|--------------|-----------|-----------|----------|-------------|--|
| To pic 0 | stud ent | class room | than k | teac her | lear n | stop | scho ol | learni ng | well | educ ation | teach er influe nces effecti venes s of classr oom learni ng |
| To pic 1 | clas sroo m | unive rsity | stud ent | histo ry | cam pus | chan ge | learn ing | scho ol | learn | onlin e | in camp us learni ng to online learni ng |
| To pic 2 | clas sroo m | educ ation | stud ent | upgr ad | gen erati on | scen ario | learn | work | cours e | world | global educ ation while workin g |
| To pic 3 | stud ent | class room | time | learn | edu cati on | univ ersit y | cam pus | year | virtual | go | virtual classr oom and educ ation |
| To pic 4 | learn | stude nt | clas sroo m | work | mba | lang uage | time | think | skill | good | Learni ng emplo yable skills throug h MBA |
| To pic 5 | job | unive rsity | lear n | class room | stud ent | mba | work | time | teach er | start | time spent on MBA and its impac t on job or work |
| To pic 6 | clas sroo m | educ ation | teac her | learn | forw ard | stud ent | mba | thank | start | techn ology | classr oom based MBA movin g |

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| | | | | | | | | | | | towards technology based education |
| Topic 7 | classroom | student | mba | learn | work | teacher | education | love | year | school | skills and emotions learning in MBA |
| Topic 8 | student | classroom | university | mba | education | help | school | get | continue | need | MBA as continual learning |
| Topic 9 | classroom | school | education | learn | student | support | teacher | need | mba | campus | MBA education support by in campus learning |
| Topic 10 | classroom | learning | university | well | country | learn | field | teach | student | play | Learning through field experience, e.g. field trips, internships, real life projects |
| Topic 11 | factor | relationship | intention | finding | effect | influence | social | implication | performance | consumer | social factors, intentions and its effects, implication and influence on consumer |

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| To pic 12 | econ omic | chan ge | cou ntry | publi c | ener gy | tech nolo gy | glob al | econ omy | policy | chall enge | challe nges in global econo mic chang e, energ y and techn ology policie s |
| To pic 13 | litera ture | mana geme nt | revi ew | stud y | kno wled ge | articl e | ident ify | appr oach | frame work | journ al | mana geme nt resear ch |
| To pic 14 | stud ent | educ ation | high | learn | lear ning | cour se | prog ram | skill | entrep reneur ial | grad uate | entrep reneur ial and skill focus ed learn ing |
| To pic 15 | lead ershi p | value | findi ng | impli cation | purp ose | appr oach | desi gn | innov ation | ethical | social | influe nce of social and ethical values and leader ship |
| To pic 16 | finan cial | firm | com pan y | touri sm | capi tal | indu stry | infor mati on | right | reserv e | mana geme nt | financi al perfor manc e and mana geme nt of touris m indust ry |
| To pic 17 | care er | work | emp loyee | job | soci al | theo ry | relati onsh ip | role | individu al | impli cation | social implic ation of work and career |
| To pic 18 | price | risk | effe ct | stock | retur n | food | sho w | find | high | earn ing | financi al perfor manc e |
| To pic 19 | netw ork | meth od | prop ose | time | sce nari o | use | proc ess | suppl y | model | mana geme nt | netwo rk and supply |

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| | | | | | | | | | | | chain scena rios |
| To pic 20 | educ ation | stude nt | desi gn | profe ssion al | proc ess | teac her | high | educ ation al | devel op | traini ng | need for profes sional trainin g |
| To pic 21 | prog ram me | mba | digit al | indu stry | stud ent | onlin e | learn ing | educ ator | covid | teachi ng | mba and digital learnin g due to COVI D |
| To pic 22 | stud ent | learnin g | tech nolog y | class room | edu cation | scho ol | teac her | world | one | onlin e | global classr ooms due to online classr oom techn ologie s |
| To pic 23 | learn ing | educ ation | lifelo ng | lifelo ng | learn ing | skill | syst em | learn er | emplo yer | traini ng | emplo yer trainin g and lifelon g learnin g for skills enhan ceme nt and devel opme nt |
| To pic 24 | acad emic | unive rsity | lear ner | valu e | cont ent | pow er | repu tatio n | entre pren eur | block | indivi dual | stude nts value univer sity's reputa tion, power and entrep reneur ial nature |
| To pic 25 | stud ent | learnin g | univ ersit y | educ ation | teac hing | hum an | scen ario | know ledge | global | work | knowl edge throug h univer sity learnin g leadin |

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| | | | | | | | | | | | g to global work |
| To pic 26 | educ ation | stude nt | univ ersit y | institut ion | high er | high er | educ ation | inter natio nal | world | learni ng | Intern ationa l and global institut ions |
| To pic 27 | skill | learni ng | figur e | uk | edu cati on | empl oyer | level | work | literac y | low | need for skill based learni ng in the UK |
| To pic 28 | busi ness | scho ol | mba | stud ent | edu cati on | busi ness | scho ol | progr am | univer sity | high er | mba educa tion as higher educa tion |
| To pic 29 | univ ersit y | high | cam pus | grad uate | com mun ity | high er | educ ation | institut ion | class | publi c | gradu ate comm unity in higher educa tion |
| To pic 30 | say | gover nmen t | covi d | case | retur n | coro navir us | state | publi c | countr y | plan | COVI D cases return and gover nment action s |
| To pic 31 | peop le | say | busi nes s | plan | wo man | com pany | cam paig n | year | black | com munit y | woma n and black comm unity |
| To pic 32 | finan cial | meas ure | com pan y | reve nue | loss | quar ter | resul t | incre ase | cash | growt h | financi al meas ures and comp any perfor manc e |
| To pic 33 | onlin e | learni ng | lear n | teac her | clas s | teac hing | univ ersit y | techn ology | teach | dista nce | online teachi ng enabl ed distan ce |

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| | | | | | | | | | | | learn ing |
| To pic 34 | say | work | pan dem ic | onlin e | lear ning | learn | tech nolo gy | covid | state | peopl e | work and online learn ing due to COVI D |
| To pic 35 | say | colle ge | univ ersit y | cam pus | go | think | high | fall | pande mic | state | going to camp us and pande mic |
| To pic 36 | say | distri ct | boar d | state | coa ch | athle te | prog ram | publi c | home | seas on | athlet e and coach es progra mme affect ed due to home workin g |
| To pic 37 | child | learn | teac her | skill | thin k | stud y | work | chan ge | devel op | exper ience | teach er skills and child devel opme nt |

15.13. Expert interview registration form

****form on the next page****

23/02/2024, 11:02

Interview interest registration form

Interview interest registration form

1. Information about the interview

Thank you for agreeing to the interview and for devoting your time. Promise, it will be a quick conversation!

The interview will be on MS-Teams at your convenient time. All the information you provide will be anonymised, treated as confidential, and will ensure that it is not attributed back to you. At anytime if you need help with this form or if you have any questions, please contact me on v.venugopal@kingston.ac.uk

So, what is this conversation about? ChatGPT and AIs in general are becoming more and more advanced and have become embedded in our daily life. So how will this impact identifying weak signals and drivers of change? I am looking for your opinion through a quick conversation.

Quick introduction about me: I am Vivek Venugopal and I am a Lecturer in Kingston Business School, and I am doing my PhD from Strathclyde Business School. Before entering academia, I worked in SME manufacturing industry for more than 10 years. I have an MBA from a top tier business school from Germany. Please feel free to connect with me on LinkedIn: <https://www.linkedin.com/in/vivekvenugopalresearcher/>

Thank you so much!

2. Full name (Only for validating unique entry)

3. Email address

4. Age group

- ☐ Under 18
- ☐ 18-25
- ☐ 26-35
- ☐ 36-45
- ☐ 46-55
- ☐ 56-65
- ☐ 65+

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5. Scenario planning OR Strategic foresight experience

- ☐ More than 10 years
- ☐ 5 to 10 years
- ☐ 1 to 5 years
- ☐ Less than 1 year
- ☐ Completely new to the field

6. Professional background

- ☐ Academic
- ☐ Consultant
- ☐ Other

7. Gender

- ☐ Woman
- ☐ Man
- ☐ Non-binary
- ☐ Prefer not to say

8. Interview date: Please click on the below 'Calendly' link to set up a mutually convenient time:

https://calendly.com/vivek_venugopal/spandai

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