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Implementation of Responsible Innovation Strategies in Multinational Technology Corporations - A Comparative Case Study

By

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Key Phrases

Responsible Innovation, Technology Sector, Technology Industry, Market Leading Firms, Pace of Innovation

Abstract

Responsible Innovation (RI) is a relatively new framework and there is limited literature on its implementation in businesses. This thesis investigates if and how three multinational technology corporations implement RI by using a comparative case study approach. The three firms chosen - Airskin, Amazon Web Services (AWS) and Autec - have significantly different market positions (size and resources to innovate) and operate in different sectors (sub-industries). This study explores how these firms' market position and sectoral pace of innovation affects their RI implementation practices and draws broader conclusions about how RI is implemented in the technology industry. Key findings are that technology firms use 1) *Customisation*, 2) *Trustworthiness of their Operations* and 3) *Acceptability of their innovations* as ways of implementing RI. The findings show that a sector's pace of innovation and a firm's market position affect these in nuanced ways, with practical implications for technology firms.

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1. Introduction

1.1.Context

The technology industry has played a central role in wide-ranging innovations, from increased automation and robotics to digitization and artificial intelligence (AI), impacting businesses, governments, and individuals over the past few decades (Ali et al., 2023; O'Connor & Wilson, 2021). While these innovations have provided immense economic benefits (Atkinson and Mckay, 2007), they have also resulted in significant externalities, such as the 'Tech Giants'[1] breaches of data privacy (Stahl & Wright, 2018), worsening sustainability (Barlatier et al. 2024) , and the automation of white collar work associated with AI (Bengio et al. 2024).

Managing these externalities is critical, given the industry's focus on innovation and its association with business longevity (Ortiz-Villajos & Sotoca, 2018; Zhang et al. 2020). Due to the intense competitive environment, firms have strong incentives to continue innovating despite significant risks (Petit & Teece, 2021). A recent example of this is the Institute for Life's (2023) failure to motivate a pause in large AI model development.

Although Tait et al. (2021) highlight the important role of regulators in addressing these risks, they often lag behind rapid technological advancements, a phenomenon known as the 'pacing problem' (Marchant, 2011). As a result, stakeholders increasingly recognize that companies themselves must tackle ethical, social, and environmental concerns (Taeihagh et al. 2021).

This acknowledgment is driving the Responsible Innovation (RI) movement, which was first conceptualised by Stilgoe et al. (2013) as a "collective stewardship of science and

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[1] A term for large, globally influential technology companies typically associated with companies such as Apple, Amazon, Google, Meta and Microsoft.

innovation" to ensure socially and ethically acceptable outcomes. They propose a framework with four key dimensions: anticipation (forecasting potential impacts), inclusivity (stakeholder involvement), reflexivity (self-examination by innovators) and responsiveness (adapting to new information and contexts). RI aims to balance innovations' benefits with their potential societal impacts, ensuring that technological advancements contribute positively to society.

1.2 Research Gap

Since its conception, research on Responsible Innovation (RI) has steadily increased, with many large scale studies having been published that show correlations between a firm's self-reported RI and performance parameters such as competitiveness (Ales-Gemio, Cruz-Cázares & Parmentier, 2020; Bel Hadj et alt 2020; Duong & Hoang, 2023; Häußermann et al., 2023; Ivanova, 2023; Lees & Lees, 2018; Nguyen et al. 2023; O & Kim, 2020; Roy, 2021). While these studies highlight commercial incentives for firms to be responsible innovators—beyond the obvious moral imperatives—there has been little research on implementing RI in a business context, despite its original intention to serve businesses more than academia. A systematic review by Lubberink (2017) attributed this to a broad perception amongst businesses that RI is still conceptually ambiguous and difficult to apply.

Since then, several studies have tried to bridge this gap. A qualitative study from Gurzawska (2021) interviewed both large firms and SMEs across several industries about their RI practices. It showed that firms recognise the importance of innovating responsibly; however, similar to the findings of Lubberink (2017), concluded that firms had limited knowledge of the RI framework as a distinct entity. Small firms lacked ways of monitoring their RI practices (e.g. procedures, documentation, self-audits) and larger firms did not make a distinction between RI practices and Corporate Social Responsibility (CSR). While CSR

addresses ethical and social implications, it does not focus on innovation, potentially limiting firms' abilities to align innovations with stakeholder pressures (Hlioui and Yousfi, 2020).

Beyond identifying these deficits, the study did not explore how firms practise responsible innovation without knowledge of an existing RI framework. Although such a study might be subject to confirmation bias, it would provide qualitative descriptions of how to implement RI dimensions for further discourse.

Li et al. (2023) addressed this by reviewing public documents from the top 100 high-tech companies, focusing on their RI implementation. Few of these firms publicly disclose RI documentation, so findings were mainly drawn from heavily resourced 'tech giants' like Meta, Google, and AWS, who primarily focused on generative AI (GenAI). In this sector, firms concentrate on building trustworthiness (explainability, data security, and transparency of operations) and acceptability (limited harm potential and equitability) of their innovations.

Though these findings were novel, the study limited its conclusions to this narrow sector and did not conduct any interviews of key personnel about their sensemaking of RI. This leaves a considerable research gap. Firstly, interviews with key innovation personnel would provide deeper insights into RI practices than shareholder-focused documentation. Secondly, expanding the study beyond GenAI would reveal how the pace of innovation and any corresponding regulation affects RI practices in different technology sectors. Finally, considering firms beyond 'tech giants' would provide insights into how market position (size and resources to innovate) affects RI implementation. Studying smaller, less resourced firms in different sectors would offer additional insights beyond focusing on global giants. Conducting a study exploring various other sectors within the technology industry would also allow for information gathering on how RI is implemented in sectors where pace of innovation also varies, since the sole focus on AI firms provides results limited to a fast paced sector (MIT Technology Review Insights, 2021).

In summary, the research gap is how market position and a sector's pace of innovation influence the implementation of RI in the technology sector. The next section discusses how this paper bridges that gap.

1.3 Research Purpose

This paper bridges the research gap by conducting a comparative case study on RI implementation in three technology firms from different sectors. These firms are selected to represent varying sectoral innovation paces and market positions.

The first firm is a 'tech giant' from the GenAI sector, known for its rapid innovation pace, building on Li et al. (2023). The second firm is a smaller, less resourced company from the robotics sector, which also has a high innovation pace but a crowded market with over 500 influential firms (Lässig, 2021). The third firm is a large, established company from the industrial automation sector, known for being traditional, slower-moving, and heavily regulated (McKinsey & Company, 2019). The selection criteria is expanded upon in the methodology section.

By examining these sectors, the study aims to provide insights into how market position and the pace of innovation affect RI implementation.

1.4 Research Questions

1. How does market positioning affect how technology firms implement Responsible Innovation?

2. How does the pace of innovation across technological sectors affect how firms implement Responsible Innovation?

1.5 Delimitations

This research employs a comparative case-study approach, limiting the generalizability of findings to the selected firms and their specific contexts. Given the scarcity of research on RI implementation in the technology industry, this approach offers valuable insights that can inform larger, more quantitative studies. The study focuses on firms accessible for detailed interviews and data sharing, which may not represent all variations in RI practices, particularly those of highly confidential operations. Additionally, by concentrating on current practices, the study does not capture long-term trends and future changes in RI implementation.

2. Theoretical Background

This section first establishes the process of extracting relevant information from existing literature, and then explores foundational frameworks for how firms formulate and execute responsible innovation strategies.

The frameworks explored here then inform the interview process by orienting the semi-structured questions in a way that prompts interviewees to discuss concepts within scope of the study's research questions. Findings can then be compared and contrasted against the literature to confirm empirical fit or identify any gaps to be bridged.

Section 2.1 gives background on the Responsible Innovation framework - the focus of this paper. Section 2.2 discusses the highly related Responsible Research and Innovation (RRI) framework, section 2.3 discusses the Anticipatory Governance (AG) framework, and Section 2.4 compares key attributes of the three literary lenses.

The RRI and AG frameworks offer similar theoretical contributions to the RI framework but differ primarily in their application context (Stilgoe et al. 2013; Guston, 2013). Given businesses' widespread confusion on these frameworks (Lubberink, 2017), using related theories can help interpret interviews and ensure fair characterization of responses. This also provides triangulation, which Flick et al. (2018) define as improving credibility and validity by interpreting results from multiple theoretical perspectives.

2.1 Responsible Innovation (RI)

Origins of Responsible Innovation

The origins of Responsible Innovation (RI) can be traced back to the early 1990s with the integration of Ethical, Legal, and Social Implications (ELSI) into major scientific initiatives like the Human Genome Project (Biomedicine et al., 1995). At the same time, the precautionary principle, advocating for cautious innovation, was established in EU law with the Maastricht Treaty of 1992 (European Union, 1992). These laid the foundation for RI's cautious approach to innovation.

In parallel, the concept of Responsible Research and Innovation (RRI) emerged, focusing initially on the scientific community. RRI emphasised a "...transparent, interactive process involving societal actors and innovators to ensure the ethical acceptability, sustainability, and societal desirability of innovations…" (Rip, 2014).

RI gained prominence with the publication of "Developing a Framework for Responsible Innovation" by Stilgoe et al. (2013). While borrowing from RRI, RI specifically extended these principles to the business context. Stilgoe et al. (2013) resisted providing as prescriptive a definition, instead advocating for "taking care of the future through collective stewardship of science and innovation in the present." They proposed four dimensions for firms to implement: Anticipation, Responsiveness, Reflexivity, and Inclusivity.

These dimensions are discussed in detail below.

Dimensions of Responsible Innovation

Anticipation

Anticipation in RI involves understanding future ethical and social impacts, as well as both intended and unintended consequences of innovations (Stilgoe et al. 2013). Firms must also balance planning for the continuance of current trends with being prepared for radically different futures (Nordmann, 2014).

Hence, there are two arms of anticipation - prediction and preparedness. This dichotomy has been highlighted by Stilgoe et al. (2013) as a key weakness of the existing framework, as anticipation is thus hard to make sense of and implement. Stone et al. (2020) expanded the framework by defining "historically informed anticipation," which encourages using historical examples of failed anticipation to guide future technological innovations. While this novel approach is promising, it has not been adapted for business applications and remains primarily within the realm of engineering education (Grunsven, 2023).

In business practice, some suggestions for effective planning have been a firm's use of risk analysis and data-driven analytics to anticipate the potential effects of their innovations (Lubberink, 2017). However, when it comes to preparedness, the inherent uncertainty in developing future technologies limits the effectiveness of relying on a single approach. In line with Sloan (2020)'s emphasis on strategic thinking and foresight, some studies have implemented this under the RI framework Fleming et al. (2021).

Inclusivity

Inclusivity in Responsible Innovation (RI) emphasises integrating diverse stakeholder perspectives and including the public in the innovation process to ensure that innovations address varied needs and align with societal values and ethical considerations. Stilgoe et al. (2013) highlight the importance of early public involvement, openness to diverse views, and continuous dialogue, while addressing power dynamics for meaningful engagement.

Practically, this means firms voluntarily disclosing information on either their practices or planned practices. One suggestion from Stilgoe et al. (2013) is to create feedback loops of public scrutiny that then feed back into firm practices. This undermines traditional hierarchical approaches and allows the perspective of stakeholders other than direct customers of firms to be considered.

Reflexivity

Reflexivity in Responsible Innovation (RI) involves a continuous critical examination of a firm's actions, commitments, and underlying assumptions. This aligns with Popper's (1989) idea that self-criticism is fundamental to science. RI requires firms to acknowledge their knowledge limitations and recognize differing perspectives from broader stakeholders (Stilgoe et al. 2013). By examining the value systems and theories shaping their approach to innovation and governance, firms can better align their practices with ethical standards. Practical methods for reflexivity include developing codes of conduct, adhering to standards, and establishing moratoriums (Stilgoe et al. 2013).

Responsiveness

Responsiveness in RI prioritises dealing with current realities. This involves firms reacting and adapting to both new knowledge and new perspectives (Stilgoe et al. 2013; Pellizzoni, 2004). It often relies on insights from the other dimensions. Firms can best respond to new knowledge when they have made allowances for it in their strategizing (anticipation), are aware of new perspectives when they have included diverse stakeholders (inclusivity), and understand their inherent vulnerabilities through reflexivity. Engaging in regulatory processes, either by complying with or shaping industry standards, is a practical way to meet stakeholder demands and adapt to changing views.

4 dimensions of Responsible Innovation

What if?
What is known?
What is likely?
What is plausible?
What is possible?

Imagining and taking into account opportunities, risks, environmental concerns, etc.

Putting research into context through the regular posing of questions regarding norms and values

What are underlying assumptions?
What are the consequences?
What are alt. approches?
How do cultural, social, and economic factors influence?

Anticipation

Reflexivity

Who should take part?
Who is in control?
Who is responsible?
Who will benefit?

Inclusion

Responsiveness

How can innovations be shaped as responsive as possible?
How can we integrate new knowledge, views and norms?

Enabling the hearing of 'new voices' that may challenge what can be narrow 'we know what's good for you' top-down approaches

Making changes as experience is gained and knowledge is built, including taking action to address any unintended consequences
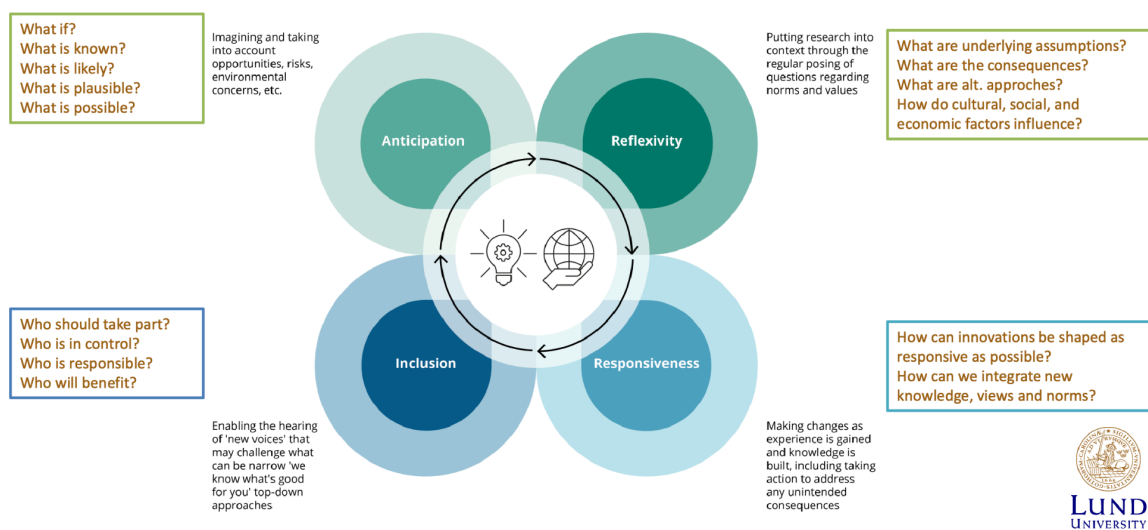
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Figure 1 - Summary of the Dimensions of Responsible Innovation (Mattsson, P., 2024)

2.2 Responsible Research and Innovation (RRI)

Responsible Research and Innovation (RRI) is frequently mistakenly used interchangeably with Responsible Innovation (RI), leading to some confusion regarding differences (Lubberink 2017). However, they have distinct origins and applications. While RI has academic roots and focuses on integrating ethical principles into business practices, RRI is grounded in policy and widely recognized within the European Commission (EC). It was implemented in a top-down manner through EU initiatives like the 7th Framework Programme (FP7) and Horizon 2020 (Liu et al., 2022).

RRI emphasises the same basic dimensions as RI—anticipation, reflexivity, inclusion, and responsiveness—but places a greater emphasis on precaution, likely due to its roots in foundational science. Additionally, RRI is a more developed framework for identifying themes on which responsibility is to be enacted, covering areas such as public engagement, gender equality, science education, open access, ethics, governance, sustainability, and social justice (Liu et al., 2022).

Including RRI in discussions provides a fuller understanding of responsible innovation by highlighting the policy-driven framework applied to research contexts. It ensures that this study captures the distinct yet overlapping goals of ethical alignment in both research and business environments, especially in firms or sectors where these two may coexist. Thus, addressing both RRI and RI in this paper helps avoid theoretical confusion and bridges the gap between research-focused frameworks and practical business applications of responsible innovation.

2.3 Anticipatory Governance

Anticipatory Governance (AG) emerged as a framework for the proactive governance of emerging technologies in the early 2000s, gaining prominence through the work of the Center for Nanotechnology in Society at Arizona State University (CNS-ASU) (Guston, 2013). AG focuses on keeping up with emerging technologies and attempts to address the "pacing problem" outlined in section 1.

Primarily focused on regulators, AG is also used by firms to better govern their processes in rapidly evolving industries. It is included in this literature section to give an alternative frame for how anticipation can be implemented, given its sometimes problematic description in the RI framework. This may be particularly relevant for firms that play an active role in shaping their sector's regulations.

AG overlaps significantly with RI, emphasising similar dimensions, albeit in more detail. These are shown below:

Foresight: Systematically exploring future scenarios to prepare for potential impacts. Example: Firms in the biotechnology sector might use foresight to predict regulatory shifts and potential public responses to new genetic engineering techniques, enabling them to adjust their research and development strategies accordingly (Ozdemir et al. 2011)

Flexibility: Creating adaptable policies and strategies to respond to new information and changing circumstances. Example: In the automotive industry, flexibility in regulatory policies can accommodate rapid advancements in autonomous vehicle technology, allowing for iterative updates to safety standards as new data becomes available (Finger et al. 2019)

Stakeholder Engagement: Actively involving diverse stakeholders to ensure the innovation process aligns with societal values. Example: In the energy sector, involving local communities, environmental groups, and industry stakeholders in the planning of new renewable energy projects can help address concerns and build support for sustainable initiatives (Richael & Halterman, 2020)

Continuous Monitoring: Regularly assessing the impacts of technologies to identify and address emerging issues. Example: In the healthcare industry, continuous monitoring of new medical devices and treatments ensures patient safety and efficacy, leading to better health outcomes and increased public trust in innovative solutions. Neuralink is a case study where the company has implemented rigorous safety trials and conducts continuous monitoring to ensure reliability of their devices (Neuroscience News, 2023).

2.4 Comparing the Frameworks

Table 1: Comparison of the Key Frameworks Studied

Aspect	Responsible Innovation (RI)	Responsible Research and Innovation (RRI)	Anticipatory Governance (AG)
Origins	Academic roots, formalised in Stilgoe et al. (2013)	Policy-driven, rooted in European Commission initiatives	Research institutes and public administrators
Scope	Innovation phase within industries	Scientific research and innovation	Emerging technologies
Intended Purpose	Guide commercial innovations towards desirable social and ethical outcomes	Embed responsibility into non-commercial research and innovation	Proactively regulate emerging technologies
Target Audience	Businesses	Innovation in mainly academic institutions	Regulators and institutions

Key Stakeholders	Customers, regulators, public	Scientists, policymakers, funding institutions	Broad range
Key Dimensions	Anticipation, Reflexivity, Inclusivity, Responsiveness	Anticipation, Reflexivity, Inclusivity, Responsiveness, Ethical Integration	Foresight, Flexibility, Stakeholder Engagement, Continuous Monitoring

3. Methodology

3.1 Literature Review

The first step of the methodology was to conduct a thorough review of existing literature on Responsible Innovation (RI) and adjacent frameworks - Responsible Research and Innovation (RRI), and Anticipatory Governance (AG). The key frameworks explored during the literature review summarised below were used as a basis for the interview process.

Primary Frame: **RI**

Supporting Frames: **RRI and AG**

RI was used as the primary framework for this study because it provides a foundation to address ethical, social, and environmental responsibilities that companies must consider while they innovate. It also suggests how companies should engage with both internal and external stakeholders. This framework can then be used as a basis for evaluating companies during the interview process, assessing their commitment to responsible innovation practices. RI also provides insights and covers existing knowledge about the research questions that this study aims to answer.

The supporting frameworks RRI and AG added complementary perspectives to RI by providing additional views on management of the innovation process. Considering these frameworks was crucial to gain a wider perspective on responsible innovation and also to appropriately frame the interviews to best understand how companies are carrying out its implementation in practice.

3.2 Research Design

3.2.1 Rationale for a Qualitative Study

This section of the thesis outlines the research design. A qualitative approach was suitable for this study due to its ability to provide deep insights into complex inner workings of companies that are not readily captured by the distribution of more rigid surveys or other quantitative analyses. The strategy and vision of multinational corporations often hinges on the messaging and expertise of leaders within the companies who possess experience and decision making capabilities based on market environments (Tipuric, 2022).

The qualitative nature of this research was also key for understanding the subtleties and variations in how strategic alignment is conceptualised and implemented across different corporate cultures and structures (Chtourou, 2020). Since this study considered companies based in various parts of the world, there were various factors that came into play for executives making strategy decisions. By engaging directly with the experiences and perceptions of high-level leadership, this study aimed to uncover how responsible innovation practices were enacted in the real world and the various methods of strategic implementations for RI.

3.2.2 Analysis Method

This thesis followed an abductive approach. Thagard and Shelly (1997) define abductive analysis as a research approach that allows for the gathering of data from various sources and then seeking patterns and anomalies amongst the data. In deciding on this approach, deductive reasoning was ruled unrealistic given the highly subjective nature of 'Responsibility' and the inductive approach would have ignored existing observations that helped frame the original research questions. Hence, by choosing the abductive approach, the research began with identifying the existing gap and having a set of incomplete observations (as stated in section 1 and illustrated in Figure 2), then collaborated with companies from various technological sectors to address this gap through their experiences and information. Thus, interviews began with generalised, standardised questions on company operations and proceeded to less-formal discussions based on how the interviewee directed and made sense of the original questions. This was in practice a semi-structured interview.
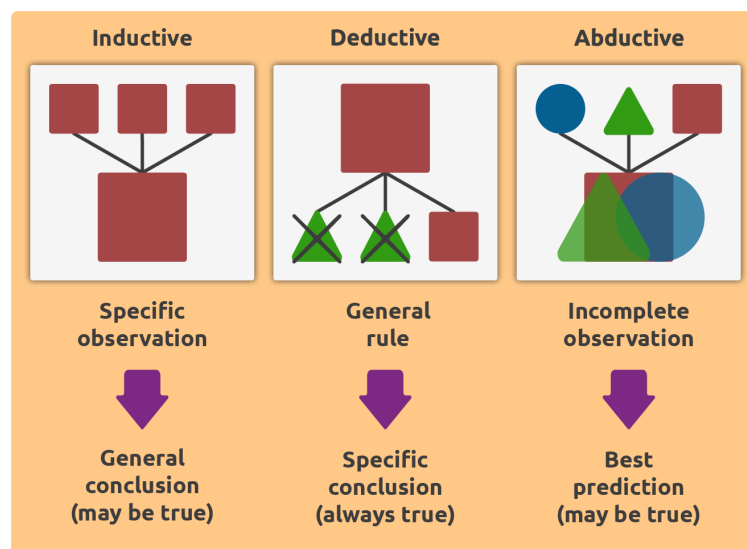

Figure 2: Selection of Abductive Reasoning and Comparisons (Jokiho and Chalmers, 2015)

3.3 Data Collection

Qualitative data was gathered through semi-structured interviews and compared to data obtained from the literature review. Details on the semi-structured interviews are outlined in section 3.3.4 below.

3.3.1 Sampling Strategy

As described in section 1.3, the focus on the technology industry was to maintain a common thread among the firms; however, based on the research gap defined, there was a need to interview companies operating in diverse technological sectors (sub-industries) with different market positions (levels of influence), and with different sectoral paces of innovation. Background research also revealed the AI and robotics sectors moved far more rapidly than Industrial Automation, which helped adjust sampling to answer research question two (Acemoglu and Restrepo, 2018; Adao and Beraja, 2024). Therefore, the formal criteria for selection was as follows:

Criteria for Firm Selection

Section 1.3 discussed the reasoning behind why each sector was chosen, however, it did not discuss the criteria for how specific firms within these sectors would be chosen. That is explained here:

- Firms must differ from one another by operating in different sectors with varying innovation paces, such as: rapidly evolving sectors (e.g., AI, robotics), and more stable traditional sectors (e.g., industrial automation).

- Firms chosen must have inter-varying levels of resources and influence within their respective markets (e.g. leaders vs pioneers).

- Firms must be willing to participate in in-depth interviews and provide access to relevant data and personnel.

The three criteria points above formed the basis for the required characteristics to conduct purposive sampling, a subtype of non-probability sampling. A purposive sample is when a researcher seeks out participants with specific characteristics, in this case companies that meet the requirements stated above (Scientific Inquiry in Social Work, 2021).

3.3.2 Company Selection

Based on the criteria above, the companies listed below were selected for interviews. Potential participants were contacted through LinkedIn or other informal means if they were previous connections.

Amazon Web Services North America

Amazon Web Services (AWS) North America represents the regional operations of Amazon Web Services, a subsidiary of Amazon.com, Inc. AWS has been a pioneer in the cloud computing arena since its inception in 2006, providing comprehensive cloud computing services that include computing power, storage options, and other functionality to help businesses scale and grow. As one of the first companies to introduce a pay-as-you-go cloud computing model, AWS has revolutionised how companies build and manage their IT infrastructure. Following the release of OpenAI's ChatGPT in November 2022, AWS boosted its integration of generative AI into its strategy, investing heavily to stay competitive in this new technological era (O'Donovan, 2023).

Justification for Selection

AWS (Amazon Web Services) was chosen as a prime example of an established market leader in the highly competitive digital technology and AI industry. AWS stood out due to its dominant position in cloud computing and AI —a sector characterised by rapid technological advances (Scheibmeir et al., 2023). The company's sustained leadership amid aggressive competition and continuous technological disruptions offered a unique perspective on learning how a leading firm integrates, prioritises, and manages responsible innovation. Studying AWS allowed for an examination of strategic initiatives in an industry where governance and regulations are still evolving, providing a unique perspective on responsible innovation practices in a fast-paced, competitive environment.

Autec

Autec is a global manufacturer of safety radio remote controls with over 35 years of experience in cableless control system development, a part of the broader industrial automation sector (Autec, 2024). Radio remote controls typically replace operators that are physically present at the machine. Overall, the radio remote control equipment market is poised for growth, with a projected increase in market size from USD 656.5 million in 2022 to USD 942.4 million by 2031, at a CAGR of 4.1% (Business Research Insights, 2024). This growth is supported by continuous innovations and the increasing necessity for remote operation capabilities in various industrial settings.

Justification for Selection

Autec, recognized for its expertise in safety-critical wireless control systems for industrial and mobile applications, represented an established player in a mature and highly regulated sector. The firm has successfully navigated the challenges of integrating cutting-edge technologies while adhering to stringent safety and compliance standards. By including Autec, this paper explored how established companies with high amounts of resources innovate within strict regulatory frameworks and in a slower paced sector.

Airskin

Airskin, developed by Blue Danube Robotics, is a company with a niche product that specialises in producing safety technology for industrial robots. Their flagship product, the Airskin safety pad, is a pressure-sensitive skin that can be applied to robots that allows up to a 90% reduction in the space robots take up on the floor by removing the cages robots are currently situated in. This technology is pivotal in enabling safer human-robot collaboration in manufacturing and other industrial settings.

Justification for Selection

Airskin, a pioneer in developing tactile safety solutions for collaborative robots, exemplified a pioneering company in a niche and emerging technology industry. As a firm that sets new standards and influences regulatory practices, Airskin's approach to innovation was critical for understanding how new technologies can reshape industry landscapes and drive industry-wide changes. Their impact on establishing new benchmarks offered valuable insights into how pioneering firms view responsible innovations and the steps they take to deploy it in practice. AirSkin showed high potential and growth vision in advancing safety in robotics and operates in a high paced sector, making it an ideal candidate for this study.

3.3.3 Company Profiles Summary

Table 2. Summary of Justification for Companies Selected

Company	Justification	Description
AWS	Market Leader in a fast paced sector	Operating as a Leader across both mature (cloud computing) and emerging (AI) digital sectors, AWS illustrated how a global leader manages the balance between driving technological innovation and adhering to ethical, regulatory, and societal expectations, profoundly influencing broad industry practices and standards.
Autec	Dominant player with significant resources in a more slowly evolving sector	Autec provided insight into how established players not leading the market use responsible innovation to differentiate and enhance competitive advantage in slower moving and highly regulated sectors.
Airskin	Pioneering firm in a rapidly evolving sector	Airskin sets industry standards and shapes regulatory practices, demonstrating how leading innovations in a niche physical technology can guide industry-wide changes and underscore the importance of pioneering responsible innovation.

3.3.4 Interviews

Interviewee Selection

To efficiently gather insights, interviews were limited to senior executives and leaders at each company. Engaging with these leaders was crucial as they possessed the overarching vision and firsthand knowledge of implementation strategies within their respective organisations. They were uniquely positioned to provide comprehensive views on the implementation of new technologies and the subsequent adjustments in corporate strategies and operations.

To ensure a balanced representation across companies and create a level playing field across various technological sectors, two interviews were conducted with leaders at Airskin, three at AWS, and five at Autec. The number of interviews conducted at each company was tailored to the specific needs of understanding their operations and implementation of RI. Autec required the most interviews due to its numerous teams working cohesively within the manufacturing process; conducting five interviews at Autec was essential to fully grasp the complexity of its operations and inner workings.At AWS, with its focus on AI, it was crucial to gather data from technical, business, and managerial representatives. Therefore, three interviews were conducted to capture a well-rounded perspective from these key areas.Airskin, being a smaller company, required the fewest interviews. Perspectives from two leaders of different teams were sufficient to answer the required questions for data collection, providing a comprehensive understanding of their operations.

Table 3. List of Interviewees

Position	Company	Medium	Date
Principal, AI Solutions Architecture	Amazon Web Services	Virtual	2024 May 1
Senior Manager, Customer Solutions	Amazon Web Services	Virtual	2024 March 8
Cloud Leader	Amazon Web Services	Virtual	2024 March 25
Co-Founder	Autec	In Person	2024 April 11
Marketing Lead	Autec	In Person	2024 April 11
R&D Lead	Autec	In Person	2024 April 11
Applications Lead	Autec	In Person	2024 April 12
Manufacturing Lead	Autec	In Person	2024 April 12
Sales Executive	Airskin	Virtual	2024 May 7
COO	Airskin	In Person	2024 April 23

Interview Process

Interviews were conducted using a combination of in-person and virtual mediums. Where in-person interviews and site visits were not feasible, virtual recorded interviews were conducted via digital teleconferencing applications. The specific interview formats were as follows:

1. **Autec:** The opportunity to tour the manufacturing facilities at the headquarters in Vicenza allowed for on-site interviews while observing the operations of various departments, including R&D, manufacturing, engineering, marketing, and strategy.

2. **AWS:** Due to the focus on the North American branch and the need for deeper access to individuals, all interviews were conducted virtually.

3. **Airskin:** Interviews were conducted both in person and virtually. At Hannover Messe, live demonstrations and presentations provided the context for interviewing executives on the exhibition floor as they explained the technology. An additional virtual interview was conducted as a follow-up for further information gathering.

Interview Structure

To maintain the exploratory nature of this thesis, semi-structured interviews were used with predetermined themes and open ended questions to begin a discussion. Through this semi-structured approach, the aim was to unveil patterns common across the companies while still allowing the interviews to have the natural flow of conversation (George, 2022). Though the basic framework of questions going into the interview were predetermined, the nature of each conversation differed based on responses and follow up questions asked to dive deeper on company specific technologies and corresponding relations to RI. To maintain a common

theme for the unstructured portion of the interviews, information from conversations was categorised into one of three groups: product innovation, innovative practices & operations, and strategic partnerships for sustainable innovation. This grouping allowed for a holistic view of each company's responsible innovation practices, with connections to internal and external stakeholders. This is also justified through analysis of Tidd and Bessant's (2018) book "Managing Innovation", where they highlight the importance of managing innovation through structured frameworks that encompass product development, operational excellence, and strategic alliances.

Interviews were all initiated in the same fashion to maintain consistency and structure. After explaining the thesis purpose, the discussion began by laying the foundation through the following questions:

1. Talk about a significant innovation that has shaped the company in recent years?

2. How does your company foster a culture that supports and drives responsible innovation strategies? Explain how you ensure they have the intended positive impacts.

3. What allows you to succeed when considering the competitive landscape

3.3.5 Ethical Considerations

All research was conducted after participants were briefed on the purpose and intent of the interviews. Consent to record and share interview information for educational purposes was obtained. Participants were informed about their right to refuse answering any questions as well as to request withdrawal from the study at any time.

Interviewee anonymity was maintained throughout the research process and personal identifiers were scrubbed from the data obtained to protect personally identifiable information.

3.4 Data Coding

Data was coded and analysed using the Gioia methodology to ensure rigorous analysis of the qualitative textual data (Gioia et al. 2013). Below is a summary of how this methodology was used in the context of this study, and the completed Gioia tables can be found in Appendix C, E, and G for Autec, AWS, and Airskin respectively.

The analysis began with First-Order Analysis, where data was extracted directly from participant observations and quotes. This initial stage involved extracting key phrases and terms used by participants to describe their experiences and viewpoints. The objective was to capture the essence of their direct expressions, ensuring an authentic representation of their perspectives.

Following this initial coding, the analysis progressed into the Second-Order Themes stage. Here, the extracted data was grouped into broader, more abstract themes. This stage was crucial as it helped identify underlying patterns and deeper insights within the data. By transforming raw observations into categorised themes, deeper meanings and connections started to emerge that went beyond the surface-level expressions of the participants.

Once these themes were established, the final step was the Aggregate Dimensions stage. The themes identified during the second-order analysis were synthesised and abstracted into broader patterns. These dimensions were vital as they represented higher-level strategic directions and were essential for developing a comprehensive understanding of the subject

matter. This synthesis allowed the development of common themes across companies, which could then be analysed to obtain generalised findings.

To ensure quality throughout the analytical process, the data was continuously observed throughout the abstraction process to ensure its validity and accuracy. This involved a dynamic comparison of emergent themes with the original dataset. This iterative process ensured that the analysis remained grounded in the data while being open to adjustments and enhancements. This rigorous approach was crucial for maintaining the integrity and depth of the qualitative analysis, ensuring that the findings were both robust and reflective of the true experiences and reflections of the participants.

3.5 Data Analysis

After the aggregate dimensions were found for each company through the data analysis process, they were analysed to identify the commonalities between the companies in order to identify observable trends and areas to begin drawing similarities. Three common themes were identified as generalised commonalities between the companies. These new themes were then defined, and then abstracted one more layer in order to connect them to broader literature and global technology industry operations. This integration helped identify new theoretical insights by exploring how the findings might extend, refine, or challenge current theories, enriching the understanding of the subject matter. The analysis was a dynamic and iterative process, with continuous refinement of themes to ensure a comprehensive examination of the data. Findings were validated through methods such as triangulation (Patton, 1999) by having the RII and AG frameworks as supplementary studies to the primary RI framework used.

3.6 Limitations

3.6.1 Industry Assortment

The study included interviews with three companies due to the limited timeframe and the priority of maintaining high-quality data. While this approach allowed for an in-depth focus on each case, it also meant that the findings may not have encompassed the wide range of experiences and strategies used by different multinational corporations in the technology industry. The smaller sample size also limited the ability to generalise the results to broader multinational corporations. Future research could expand the number of participating companies and include a broader array of industries to enhance the generalizability of the findings.

3.6.2 Sensitivity of Information

Responsible innovation is often a key competitive advantage for many companies. The public nature of this study led to some executives being hesitant to share their latest innovative advancements. This issue was particularly pronounced with private companies, which are not obligated to publish quarterly and annual reports. Their reluctance to participate to maintain privacy limited the breadth of insights into current innovative practices. Overcoming this limitation in future studies could involve ensuring stricter confidentiality measures or anonymizing company identities to encourage more open sharing of sensitive information.

3.6.3 Time Constraints

The study was conducted over a limited period, which constrained the ability to observe long-term trends and the evolution of responsible innovation practices. A longitudinal approach in future research could provide more comprehensive insights into how these practices develop and change over time, offering a deeper understanding of their long-term impact on corporate strategy and operations.

4. Empirical Findings & Analysis

This section discusses the results gathered from the interviews from the participating companies. The first part of the section analyses the companies separately, aggregating interview responses from the semi structured conversations for each company. Following the presentation of aggregated data, analysis was conducted using the Gioia methodology (Gioia et al. 2013) to develop common themes across the companies. These themes were then further explored in section 5 to assess the links to the responsible innovation framework through the research questions, as well as to develop generalised ties in a global context.

4.1 Data from Companies

The findings below were the key highlights and excerpts from the semistructured interview. Full findings from the Q&A sessions can be found in Appendix B, D, and F.

4.1.1 Key Findings: Autec

Product Innovation

When asked to discuss responsible innovation within the company, a recurring theme of the conversations was the customisation process that allows Autec to adapt to varying customer needs and be a player in various industries that need industrial remote controls. Autec's key innovation is developing highly customisable products, with up to 2000 unique configurations per year, and 70+ base configurations of remotes that form a platform that they can customise further based on needs. This also feeds into their competitive advantage.

"We want to innovate from market demands to ensure that there is a need for our products within the industries we operate. "

Autec also emphasised the development of custom software for tasks like production monitoring and project management, enhancing internal processes and operational efficiency. By developing these software applications in-house, they are able to ensure high quality production and tracking.

Additionally, Autec's focus on R&D allows the company to remain curious and agile. This department has a heavy focus on testing and the development of potential future products. Having a robust R&D team enables the company to ensure adequate field testing and confidence in prototypes before they turn into production components. For example, this team is currently working on new products such as video streams in their radios.

Innovative Practices & Operations

Autec follows responsible innovation practices by focusing on core competencies and improvements through the Kaizen methodology, avoiding falling into market traps just because they are trending (e.g. AI). The Kaizen methodology is universally adopted across the company, which revolves around continuous improvements and small positive changes as opposed to radical top down changes to achieve transformation. Using this methodology allows for swift configuration and adaptation of the products. By focusing on incremental improvements, Autec avoids rushed innovation and leaves itself the time and preparation necessary to focus on safety and reliability of the end product.

"Kaizen is not just a methodology; it's a philosophy that drives continuous improvement and empowers everyone to contribute to the process, ensuring our innovations are always moving forward. "

Safety has always been a core part of Autec's company culture. Their website is named "autecsafety.com" to emphasise to employees and customers where their priority lies, and taking a look at their past work with customers highlights that they hold this value with high regard. The company performs several thorough feasibility and compliance checks for all their products along with traditional durability and strength testing.

Safety is a critical aspect of Autec's product strategy, particularly as the market sees an influx of low-quality competitors from regions like China. These competitors often replicate high-tech products without a corresponding emphasis on safety or quality, presenting risks that are detrimental to reputable brands focused on maintaining high standards.

"The lack of focus from those manufacturers represents significant risks that undermine the integrity and reliability of products in the market, posing a threat to brands committed to maintaining high standards."

Strategic Partnerships for Sustainable Innovation

Autec focuses on finding inefficiencies and bridging gaps to streamline their manufacturing process. One example of this is the emphasis on automation of repetitive tasks, such as battery packing through use of robots. Careful selection of partnerships also plays a pivotal role in Autec's innovative operational methods. Autec collaborates with a wholly owned subsidiary specialising in joystick manufacturing, whose strengths complement and enhance Autec's product offerings. Autec has been able to meticulously balance in-house innovation with strategic partnerships, which allows them to pursue their global expansion ambitions.

Autec's presence in over 40 countries, including strategic markets like Canada, India, and Mongolia positions it well for global reach.

4.1.2 Key Findings: Amazon Web Services

Product Innovation

While AWS is a cloud services platform, since the release of ChatGPT in 2022 a lot of the innovation has been focused around developing various use cases with generative AI. For example, AWS recently launched Amazon Q, an expert on AWS that writes, debugs, tests, and implements code. With the AI boom, AWS has to ensure that they remain agile and take a proactive approach to developing AI based technology. Security is a top priority, often referred to as 'job zero' within the company, underscoring its importance in everything they do. Users can apply custom security measures based on the sensitivity level and of the data.

"Security is everything, including how models are hosted, how data is shared, whether customers can encrypt their data, and who can see the data or use it to further enhance the models"

Amazon supports the idea of customers bringing their own large language models (LLMs) and hosting them on AWS, enhancing flexibility and control over data. The focus on allowing customers to customise and freely select AI models, including bringing their own, is a part of Amazon's broader initiative of customers retaining ownership of data.

"The advantage we see from AWS's perspective is the choice of models. We're not locking customers into one specific model."

This flexibility allows AWS to cater to a wide range of customer needs, ensuring that each client can configure services to their specific requirements. The strategic adaptations

observed in AWS's response to AI and customised product strategy reflect the importance of aligning innovation with broader business goals, as discussed in Henderson and Venkatraman's (1993) work on strategic alignment.

Innovative Practices & Operations

Amazon's approach to fostering a culture of responsible innovation centres on several key strategies. At the heart of their responsible AI initiative is setting clear boundaries for how AI operates, with built-in guardrails to ensure models don't train themselves unchecked.

"We've focused heavily on explainability. If the model outputs X or Y, you should know the reasons why it predicted that."

AWS has also undergone significant organisational restructuring to better align with industry needs and enhance its process innovation. The new reporting structure enables faster escalation procedures since leaders are more localised, and builds a heavy focus on teams that can quickly mobilise and develop AI solutions for customers globally.

Amazon also adopts a trial-and-error approach to define and refine regulations, aiming to set industry standards in cases where there are none formally defined.. For example, they adhere to and help shape security standards like the OWASP top 10, positioning themselves as both contributors to and early adopters of industry-wide standards.

Strategic Partnerships for Sustainable Innovation

Strategic partnerships are a cornerstone of AWS's approach to innovation. Recognizing the limitations of working in isolation, AWS has formed key alliances with leading AI firms like Anthropic. These partnerships enable AWS to accelerate the development and delivery of advanced AI products to their customers. AWS supports open-source initiatives, contributing

to and integrating with projects like Facebook's LLaMA and other successful open-source models. This approach not only enhances AWS's innovation capabilities but also provides customers with a broader range of tools and options.

"Amazon has also recognized that partnerships will get us to move faster and deliver products for our end customers. For example, the models like Titan are good, but they are not at par with models from Anthropic or OpenAI. So in that space, Amazon has partnered with Anthropic to leverage their advancements"

The company also actively collaborates with governments and regulatory bodies to shape and comply with emerging regulations, ensuring that their innovations adhere to the highest ethical standards. AWS also emphasises transparency and explainability in AI, striving to make their AI models as understandable and controllable as possible. AWS's strategy is not solely about leading the market but also about providing value through collaboration and choice, ensuring that customers have access to the best possible technologies to meet their needs.

4.1.3 Key Findings: Airskin

Product Innovation

Airskin's core product, a pressurised "skin" system for robots, allows the robots to operate safely alongside humans and has changed manufacturing plant layouts by saving up to 90% of floor space. This technology is not only applied to robots but also extends to Automated Guided Vehicles (AGVs), End-of-Arm Toolings (EoATs), and other moving machinery. Robots equipped with Airskin can perform tasks up to six times faster than traditional collaborative robots (cobots) while maintaining high safety standards, evidenced by their PL e, Cat. 3 / SIL 3 certifications. Additionally, Airskin offers flexible and customisable

solutions that can be integrated with major robot manufacturers like Kuka, Fanuc, and Staubli. This customisation allows customers to adopt Airskin technology regardless of the specific hardware they are using in their manufacturing processes.

Innovative Practices & Operations

Airskin operates in a highly regulated and rapidly evolving industry, and embodies a culture of responsible innovation practices by integrating advanced safety technologies into their product. Airkskin commits to maintaining a high level of safety by offering comprehensive training programs to their partners. These training initiatives are designed to ensure that all parties involved in the deployment and operation of Airskin-equipped systems are well-versed in best practices for safety and efficiency.

"We create safety concepts that are really important for ensuring flexibility and the full potential of automation in production layouts"

Strategic Partnerships for Sustainable Innovation

Airskin strategy also includes a strong focus on partnerships and collaborations. By working closely with leading robot manufacturers and integrating their feedback into product development, Airskin ensures that its offerings are closely aligned with the latest trends and customer demands in the automation industry.

Airksin global outreach, with applications installed in over 40 countries, allow them to gain diverse insights and maintain a broad market presence. This global perspective enables Airskin to anticipate and respond to the varying needs of international customers, further strengthening its position in the competitive landscape. Airskin demonstrates its ability to

provide customised offerings by acting as a system integrator and expanding its applications beyond fixed robotics to areas like line manufacturing.

4.2 Common Themes

Through the semistructured data collection process above, each interview exhibited key themes. The interview transcripts, conversations, and data from factory tours were aggregated with the goal to converge on themes that were seen across all three companies. As mentioned in the methodology section, the Gioia analysis was used for this transformation of data (Gioia, Corley and Hamilton, 2013). The output tables from this analysis for Autec, AWS, and Airskin led to the development of common themes that can be found in Appendices C,E, and G. The following themes are common across the companies for what they all view as key components for the implementation of responsible innovation. This section defines and expands upon the common themes observed, while the subsequent section discusses the broader implications and connections to literature for each one including relevance to the specific RI framework pillars.

4.2.1 Theme 1: Customisation

In the context of Responsible Innovation, customisation involves tailoring products, services, and solutions to meet the specific needs and values of diverse stakeholders. This approach ensures innovations are ethically acceptable, socially desirable, and sustainable. Customisation has evolved significantly across technological sectors such as AI, IoT, robotics, and manufacturing, particularly in the Industry 4.0 era. These technologies enable manufacturers to create highly customised products, catering to individual or niche demands. Participants in this study highlighted that customisation is crucial for implementing responsible innovation, although the specific strategies varied depending on each company's market position and sector (Wolniak & Grebski, 2023).

As a summary to section 4.1: Airskin's tailored product offerings, Autec's incremental customisations, and AWS's flexible service configurations all highlight different strategies for integrating customisation into their operations to meet the unique demands of their respective markets.

4.2.2 Theme 2: Creating Trust in Company Operations

Creating trust in company operations is essential for maintaining stakeholder confidence and ensuring sustainable business practices. This theme focuses on how companies build and maintain trust through transparency, accountability, and responsiveness to stakeholder needs. The findings across interviews showed that these companies are all striving to be transparent in their operations by maintaining or increasing a focus on their public messaging and allowing external parties to gain more insights into internal operations in order to create a more transparents work culture around innovation.

Autec's focus on rigorous compliance testing procedures, pilot programs with trusted end-users, and pushing for high standards of safety allow them to build trust in their company operations (For the full findings see Appendix B). As seen through the data section above, AWS focuses on the transparency and explainability of their AI and cloud services. By opting for clear communication about security measures and allowing customers to retain control over their data, AWS seeks to build a high level of trust and reliability in their operations. Airskin enhances trust by improving human-robot collaboration and safety. They prioritise high safety standards and continuously seek certifications to validate their products.

4.2.3 Theme 3: Advocating Acceptability of Innovations

This theme explores how companies enhance the acceptability of their innovations through inclusivity, reflexivity, and responsiveness to market and regulatory demands. Promoting their innovations involves aligning customers, regulators, and the public to demonstrate societal benefits, which is crucial for implementing responsible innovation strategies (Jahansoozi, 2006). Gaining stakeholder approval is essential for sustaining business in competitive markets. By actively promoting acceptability, companies show their commitment to ethical practices, transparency, and responsibility (Gurzawska, 2020). This theme was frequently mentioned in interviews, as companies emphasised the importance of conveying the right messages to keep customers informed about the latest trends, improvements, and applications of their technology.

Autec best displayed this theme by striving to innovate without using industry buzzwords and focusing on meeting customer demands. Using incremental improvements, Autec avoids rushed innovation and leaves itself the time and preparation necessary to ensure safety and reliability of the end product. AWS placed a strong emphasis on setting guardrails for their AI innovations to ensure they operate within ethical boundaries. They advocate for the 'right regulation'—policies that protect users while still encouraging innovativeness. Since AWS is in an industry that sees regulations lagging innovations (Marchant, 2011), they are in a unique position to be an early adopter as well as a contributor to new emerging policies. At Airskin, to ensure their innovations have the intended positive impacts, they conduct thorough risk assessments and safety evaluations as part of their development process. These assessments ensure that each new product not only meets regulatory safety standards but also aligns with the company's commitment to delivering safe and effective automation solutions.

5. Discussion

The discussion critically compares the research findings against the RI framework and where appropriate, the RRI and AG frameworks. Under each theme, the influence of market position and pace of innovation is analysed in order to provide answers to the research questions of this study and to further explore implications for corporations in implementing innovation practices in different firm contexts.

5.1 Theme 1: Customisation

Parallels can be drawn between the customisation theme and the RI dimensions responsiveness and anticipation. A customised product lineup allows firms to "focus on real-time adaptation to stakeholder needs" (Stilgoe et al. 2013). It enables firms to predict future preferences using up-to-date data and prepare for fundamental changes in stakeholder demands with a flexible product offering (Wolniak, R. and Grebski, W., 2023). This exemplifies Nordmann's (2014) assertion that being anticipative requires balancing the prediction of obvious futures with preparation for unexpected ones. This proactive approach aligns with the anticipation pillar of the Responsible Innovation (RI) framework and the foresight pillar of the Anticipatory Governance (AG) framework, both emphasising the importance of vision and responsiveness to future scenarios. By adopting these anticipatory practices, companies can better navigate complex market landscapes and develop practical strategies for implementing RI practices.

Market position influences customisation approaches, with well-resourced firms using modularity to balance preparedness with anticipation (Wang et al. 2014). This means a common strategy seen is having the building blocks of product offerings ready, and then customising these to stakeholder demands (Ganji et al. 2018; Meredith et al. 1994). The

results of this study also suggest that larger, market-dominant firms may prefer this approach due to a broader range of established stakeholders. Smaller firms with less resources to innovate, meanwhile, can favour wholly customised solutions instead of modularity due to fewer stakeholders (Rodríguez-Escudero et al. 2023). This is seen through the emerging firm interviewed in this study since they must alter their solutions completely based on the end users. Both versions of the customisation strategy observed in this study highlight that anticipation and responsiveness are crucial for responsible innovation. These traits enable firms to proactively and reactively address market demands while maintaining stakeholder engagement.

The pace of innovation also influences customisation strategies. In slower-paced technology sectors, companies rely on stable but more complete modules of their product offerings (Wang et al. 2014). For instance, this may be complete products that now form a platform based on earlier tailored solutions for a previous customer. This contrasts with fast-paced sectors, where firms use less-developed, unstable modules to allow quick iteration and development on top of them (McKinsey, 2023 b). Well-resourced firms can also quickly turn unstable modules into workable products through partnerships or acquisitions, which shows their ability to be responsive to stakeholders and rapidly changing market conditions.

5.2 Theme 2: Creating Trust in Company Operations

There were significant similarities drawn from this theme and the dimensions of inclusivity and reflexivity of the RI framework. Stilgoe et al. (2013) talk about "inclusively opening up visions, purposes, and questions" to a wide set of stakeholders in order to build confidence in the company's operations. The variety of voices and opinions engaged allows for the development of a more diverse innovation process, which builds a stronger foundation for

ensuring that the outcomes are socially desirable and broadly supported (Hundschell et al. 2021)

Reflexivity is also a key part of building trust as it encompasses a firm's ability to self-criticise and transparently address its shortcomings and ethical challenges, aligning with the RI framework's emphasis on organisational improvement and stakeholder engagement. This process involves continuous self-assessment and open communication about the company's practices (Stilgoe et al. 2013). During this study, firms demonstrated their commitment to internal audits and stakeholder feedback surveys as methods of identifying key areas for improvement in company practices.

Firms across various market positions establish trust using different methods. In highly regulated environments like industrial robotics and manufacturing, they rely on independent certifications and pilot programs with trusted end users to assure stakeholders. Obtaining certifications and official standards ratings can validate a company's offerings through third-party accreditors. For example, certifications like ISO 9001 for quality management and ISO 14001 for environmental management are certifications commonly seen in the manufacturing sectors that allow companies to demonstrate their adherence to strict quality and environmental standards (Kawasaki Robotics, 2023).

Additionally, influential and market leading firms benefit from using their brand and executive reputation to develop trust and exhibit inclusivity through public messaging, technology conferences, and transparent top-down communication from leaders. Examples of this can be seen through the tech giants (i.e. Google, Amazon, Microsoft, Apple) holding public conferences to announce new products and advancements. While the root of these conferences may be commercial, they allow stakeholders to gain transparency and insights into the operations of what each company is working towards (PRLab, 2023).

The pace of innovation is also a key consideration for firms to build trust. In slower-paced industries, companies emphasise quality control and incremental improvements, maintaining continuity in their base product offerings with a platform-based customisation approach. Conversely, fast-paced industries prioritise transparency and the explainability of internal processes, ensuring clarity and consistency in public messaging. This is shown throughout this study with AWS when they focus on the explainability of AI as being a key aspect of building trust with stakeholders. Taking AI as an example, other studies have also shown that transparency and explainability are vital for building trust with external stakeholders. Emphasising explainability helps build their confidence and assures users of what to expect when interacting with the specific technology (Abedin, B., 2021; Agostinho et al. 2023).

Through this study it was seen that companies in both fast and slow moving sectors recognise the importance of developing internal capabilities through creating sophisticated training programs. This initiative aligns with the inclusivity dimension of RI and shows that companies open to investing in their employees are able to build a skilled workforce and further support their trust building efforts with highly qualified workers. External studies also show the importance of investing internally in order to expand organisational capabilities and trust, and discuss how investing in employees through training programs not only strengthens trust externally but also demonstrates that a company is committed to internal growth and development (Skurzak, 2023; APM, 2023).

5.3 Theme 3: Advocating Acceptability of the Specific Innovations

This study's results extend the findings of Li et al. (2023), showing that technology firms focus on the acceptability of their innovations by demonstrating utility, equitable benefits, and limited harm potential. The effects of market position and pace of innovation appear more intertwined on this theme, making the findings highly contextual.

Market leaders often play a role in actively shaping regulations (Hays, 2019), however this depends on the sector's pace of innovation. Market leaders in fast-moving sectors (in this study, AWS) appear to influence regulation not only to gain competitive advantages, but also to demonstrate the limited harm potential of their technology. This often extends, at least in the digital sectors, to open-sourcing some of the building blocks of their technology, in order to allow for public peer review and equitable distribution of the innovations and new knowledge (Google Open Source, 2024). This finding aligns with a long tradition of open sourced components in the digital sectors (GenAI, cloud, software), which through the lens of RI may be understood as a way ensuring inclusion and reflexivity given a practical inability to predict how emerging technologies will influence stakeholders. This also may be considered a form of anticipatory self-governance.

Even if market-leaders in fast-paced sectors do not actively shape regulations, they often rely on advisory boards or ethical committees to guide their processes, allowing them to align with societal expectations (Board-room.org, 2023). By leveraging the expertise of advisory boards and ethical committees, they can better navigate regulatory landscapes, implement best practices, and address potential risks and ethical concerns (BMC Health Services Research, 2023). This also relates back to the reflexivity pillar of the RI framework since firms have to be self critical in order to assess the validity and impact of their innovations.

Market-leaders in slower industries also address acceptability, however, given the presence of more developed regulation, they often focus on compliance more than shaping it. This leads to incremental innovation approaches as often innovation comes from specific market demands (Calvano & Polo, 2021). This means the innovation is less subject to public scrutiny and companies rely more on governance structures to ensure the outcome has limited harm potential (Karlsson, & Tavassoli, 2016). This can be a potential risk for responsible innovation since overreliance on existing governance structures can hinder the ability for a company to anticipate and be reflexive.

Smaller, less-resourced firms have less influence on regulations and less ability to have dedicated advisory committees. Instead, they tend to focus on making transparent risk-analyses and producing high quality products that comply with and even exceed necessary regulations (Adnan et al. 2018). This again is a form of self-governance where these firms have been reflexive in identifying their products potential for harm and inclusive in being transparent with how they assess their technology (Clausen et al. 2012).

5.4 Contributions and Future Research

5.4.1 Contributions

This study addresses a notable research gap in understanding how companies, particularly those in the technology sector, implement Responsible Innovation (RI). Previous efforts, such as the systematic review by Lubberink (2017) and subsequent studies by Li et al. (2023) and Kurzawska (2021), have made strides in this area but often with significant limitations.

Building on these prior findings, this study conducted qualitative interviews with executive staff at technology firms, focusing on sectors like AI, Robotics, and Industrial Automation. It examined how market position and the pace of innovation within these sectors influence the

implementation of RI. The study identifies three key themes that companies use to make sense of RI:

Customisation: Firms use customisation to align with the responsiveness and anticipation dimensions of RI. This involves real-time adaptation to stakeholder needs, predicting future preferences, and preparing for changes with flexible product offerings. Larger firms often use modular strategies, while smaller firms may focus on wholly customised solutions due to their limited resources.

Building Trust in Operations: Trust is established through inclusivity and reflexivity. Companies engage a wide range of stakeholders to build confidence and ensure diverse perspectives in the innovation process. Reflexivity involves self-criticism and transparent communication about company practices. Methods to build trust vary by market position and regulatory environment, with larger firms leveraging certifications and public messaging, while smaller firms focus on direct stakeholder interactions.

Advocating Acceptability of Innovations: Firms promote the acceptability of their innovations by demonstrating utility, equitable benefits, and limited harm. Market leaders in fast-moving sectors often shape regulations and use open-source technology to ensure inclusion and reflexivity. Slower sectors focus on regulatory compliance and incremental innovation, ensuring limited harm and equitable effects.

5.4.2 Future Research

Future research should expand this study to include additional sectors of the technology industry, providing a more granular view of different paces of innovation and market positions. Conducting a further study including sectors such as energy, biotechnology, automotive, etc. will highlight sector specific nuances that should be considered when tuning

the RI framework to become a more practical tool. Having a larger sample size will also allow for the development of additional themes that allow firms to use the RI framework as a template.

Additionally, each of the themes discussed above will have their own drawbacks and associated challenges. Therefore, future studies should consider counterpoints to the implementation strategies for RI discussed in this paper and validate against empirical data of companies that do not categorise themselves as having a customisable product line, or have failed to build trust and acceptability of their organisational image and technology.

After a comprehensive study has been done, it would also be beneficial to develop metrics for assessing RI implementation within organisations. Indicators for assessing the RI practices could create a comprehensive toolset that companies can use to benchmark against others and continuously improve their responsible innovation scores.

5.4.3 Implications for Practice

This study provides practical guidance for technology firms on implementing responsible innovation. Companies should focus on customising their innovations to meet diverse stakeholder needs, building trust through transparency and accountability, and advocating for the acceptability of their innovations by demonstrating their utility, equitable benefits, and limited harm. These practices can enhance the social desirability and sustainability of technological advancements, ensuring that they contribute positively to society.

For a technology firm looking to the Responsible Innovation framework for guidance, this study suggests two important ways in which they can help decide how to implement RI more effectively. The first is to consider their market position and the second is to consider how rapidly evolving their sector is. Based on these factors, the firm can more specifically apply methods such as customisation (e.g modularity or wholly custom), building trust (explainability or pilot programs) and acceptability (e.g. shape regulations or transparency in risk assessments). This will better assist and motivate firms to remain engaged with the RI framework.

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Appendices

Appendix A: Summary of Interpretations from Empirical Data:

Themes Observed in Interviews	Analysis for Autec	Analysis for AWS	Analysis for Airskin
Responsiveness to customer demands through customisation	Autec's strategy of offering highly customisable products demonstrates their commitment to meeting diverse customer needs, which enhances their competitive advantage.	AWS's focus on generative AI and customised solutions reflects their strategy to stay ahead in a competitive market by identifying a specific customer problem and working backwards from it.	Airskin's approach to custom fittings ensures their technology can be integrated widely, positioning them as a flexible and adaptable player in the robotics market.
Building Trust	By avoiding market trends like AI, Autec emphasises ethical responsibility and quality, which may strengthen customer trust and loyalty in highly regulated markets.	AWS's strict security measures and emphasis on customer data ownership reflect their commitment to ethical practices, which could be a significant market differentiator.	Airskin's dedication to improving human-robot collaboration and safety highlights their ethical commitment, potentially boosting their reputation in the industry.

Creating Acceptability of Technology	Autec's development of robust products and processes to meet high regulatory standards showcases their dedication to maintaining compliance, which is critical in their industry.	AWS's responsiveness to market trends and customer demands through strategic AI solutions shows their agility and customer-centric innovation approach.	Airskin's versatile product offerings and global outreach demonstrate their proactive stance in anticipating and meeting diverse international market needs.

Appendix B: Autec Interview Questions

Q: Tell us about a significant innovation that has shaped the company in recent years

Autec has many key innovations that allow them to remain a key player in the market and keep improving significantly. The core innovation for Autec is the customisation process that allows them to adapt to varying customer needs and be a player in various industries that need industrial remote controls. Autec's innovation of developing a highly customisable product, with up to 2000 unique configurations per year is also their key competitive advantage since it allows them to "innovate from market demands".

The customisation also applies to Autec internally. They develop custom software in house for various tasks like production monitoring, Q&A, and project management (PM) . The PM software also connects to visualisation tools that each team has displayed in their respective work areas to monitor progress. In house innovation in a heavily regulated industry requires more attention to detail as there is a greater need for robustness in products and processes, however it allows Autec to ensure that they are meeting the high standards for monitoring and Q&A that customers expect from a high end manufacturing company.

Additionally, Autec's focus on R&D allows the company to remain curious and agile. This department has a heavy focus on testing and the development of potential future products. Having a robust R&D team enables the company to ensure adequate field testing and confidence in prototypes before they turn into production components. For example, this team is currently working on new products such as video streams in their radios.

Q: How does your company foster a culture that supports and drives responsible innovation strategies? Explain how you ensure they have the intended positive impacts.

In the manufacturing/industrial technology space, there are heavy regulations that limit the pace of innovation. This also makes responsible innovation extremely vital, as mistakes and errors in production can have heavy repercussions.

Autec follows responsible innovation by focusing on core competencies and improvements through the Kaizen methodology, avoiding falling into market traps just because they are trending (e.g. AI). The R&D team explained that trends like AI are often seen in the manufacturing industry as well, but Autec strives to innovate without using industry buzzwords and focuses on what actually matters for meeting customer demands. The Kaizen methodology is universally adopted across the company, which revolves around continuous improvements and small positive changes as opposed to radical top down changes to achieve transformation. By focusing on incremental improvements, Autec avoids rushed innovation and leaves itself the time and preparation necessary to focus on safety and reliability of the end product.

Additionally, Autec instils a culture of responsible innovation by making their company values clear and focusing on quality. All products are made in Italy so that the company can verify the quality. Their website is named "autecsafety.com" to emphasise to employees and customers where their priority lies, and taking a look at their past work and customers highlights that they hold this value with high regard.

The combination of having 35+ years of experience and being a top player in the market has allowed Autec to carve out additional failsafe procedures to stay ahead and ensure that their public image becomes synonymous with trust. The company performs several thorough feasibility and compliance checks for all their products along with traditional durability and strength testing.

Due to their time in the market, Autec has struck a balance between pace of innovation and responsibility of what they output. Their R&D team has the culture of always experimenting and their software is focused on quick changes, while the overall products introduced to the market are carefully inspected and tested.

Q: What allows you to succeed when considering the competitive landscape

In assessing the elements that contribute to success within a competitive landscape, it is crucial to consider several strategic practices and principles. First, the automation of repetitive tasks, such as battery packing, streamlines operations and enhances efficiency. Autec, for example, has capitalised on this by automating essential processes.

Careful selection of partnerships also plays a pivotal role. Autec collaborates with a wholly owned subsidiary specialising in joystick manufacturing, which underscores the importance of aligning with partners whose strengths complement and enhance one's product offerings. Furthermore, Autec has strategically opted for external expertise for the development of battery charging stations that are customised to optimise both the precision of charging and the longevity of the batteries.

Understanding the balance between in-house operations and external partnerships forms a key success criterion. While maintaining processes in-house enhances visibility across the end-to-end production line, partnerships with specialised firms can yield superior quality outputs. This balance allows companies like Autec to leverage the unique benefits of both approaches effectively.

Global expansion ambitions and a comprehensive understanding of the international market landscape are equally significant. Autec's presence in over 40 countries, including strategic markets like Canada, India, and Mongolia positions it well for global reach. Notably, India's increasing importance in Autec's strategy reflects a strategic pivot away from markets like China.

Safety is a critical aspect of Autec's product strategy, particularly as the market sees an influx of low-quality competitors from regions like China. These competitors often replicate high-tech products without a corresponding emphasis on safety or quality, presenting risks that are detrimental to reputable brands focused on maintaining high standards.

The diversification of suppliers is another cornerstone of Autec's strategy, especially given the current volatility in global supply chains. This diversification ensures a more stable and reliable supply network, critical in times of uncertainty.

Finally, Autec's approach to innovation distinguishes it from competitors. By developing a platform of 70-80 base models of radio control, Autec lays a foundational framework that supports extensive customisation. This enables the rapid delivery of tailor-made remotes to customers, contrasting sharply with competitors who may rely more on standardised, off-the-shelf models.

Together, these strategies delineate a comprehensive approach to navigating and succeeding in a competitive environment, highlighting the multifaceted strategies companies like Autec deploy to secure their market position and drive growth.

During interviews and facility tours, several key themes emerged that closely align with responsible innovation principles.

Staff identified the Veneto region as crucial to Autec's success. Unlike the German Ruhr region, known for systematisation and standardisation in heavy industry, Veneto companies

excel in producing highly specialised, customised products in smaller batches. This focus on customisation aligns with responsible innovation's emphasis on responsiveness to customer demands.

The diversification of suppliers within Veneto was also highlighted. The owner compared this practice to ASML, stating that a diverse supplier base is key to success. This approach ensures supply chain stability and resilience, which is essential for risk management and maintaining high quality standards.

Challenges in breaking into the US market were noted, particularly due to stringent mechanical standards which staff felt were unjustified within their more electronic technical sector, and also competition for technical staff in regions like Minnesota, dominated by the med tech industry. This reflects the anticipatory dimension of responsible innovation, where Autec must navigate regulatory and market challenges to succeed.

Employees consistently emphasised the importance of having the right people over other expansion strategies. This focus on human capital aligns with the inclusion dimension of responsible innovation, highlighting the importance of skilled and dedicated staff in driving innovation and maintaining ethical standards.

Appendix C: Autec Data Analysis Table

1st Order Concepts	2nd Order Themes	Aggregate Dimensions
"Autec's core innovation is the customisation process that allows adapting to varying customer needs."	Emphasising Customisation	Responsiveness to Customer Demands through Customisation
"Autec develops custom software in-house for tasks like production monitoring and project management."	In-House Technological Development	Creating acceptability of technology
"Focus on R&D allows Autec to remain curious and agile, working on new products like video streams in radios."	Investing in Research and Development	Creating Trust in Company Operations
"Adopting the Kaizen methodology for continuous improvements and small positive changes."	Continuous Improvement Practices	Efficiency and Performance through trusted company operations
"Autec's products are made in Italy to ensure high quality and reliability."	Maintaining High Product Standards	Trust in Company Operations

"Thorough feasibility and compliance checks are performed for all products."	Ensuring Rigorous Testing and Compliance	Advocating for acceptability of technology
"Automation of repetitive tasks such as battery packing streamlines operations."	Operational Efficiency Through Automation	Advancing Company Operations
"Partnerships with specialised firms for superior quality outputs."	Leveraging External Partnerships	Collaboration and Partnerships
"Expanding global presence with a focus on high safety standards and industrial activity."	Strategic Market Expansion	Versatility and Interoperability
"Diverse supplier network to ensure stability in global supply chains."	Ensuring Supply Chain Resilience	Risk Management and Mitigation

Appendix D: AWS Interview Questions

Q: Tell us about a significant innovation that has shaped the company in recent years

I'd lead with Generative AI ("GenAI"). Much of the early public attention has focused on GenAI applications, with the remarkable 2022 launch of ChatGPT. We're also building several apps in AWS, including arguably the most compelling early GenAI use case—a coding companion. We recently launched Amazon Q, an expert on AWS that writes, debugs,

tests, and implements code, while also doing transformations (like moving from an old version of Java to a new one), and querying customers' various data repositories (e.g. Intranets, wikis, Salesforce, Amazon S3, ServiceNow, Slack, Atlassian, etc.) to answer questions, summarise data, carry on coherent conversation, and take action. Q is the most capable work assistant available today and evolving fast.

Q: How does your company foster a culture that supports and drives responsible innovation strategies? Explain how you ensure they have the intended positive impacts.

Amazon's approach to fostering a culture of responsible innovation centres on several key strategies. At the heart of their responsible AI initiative is setting clear boundaries for how AI operates, with built-in guardrails to ensure models don't train themselves unchecked. Security is a top priority, often referred to as 'job zero' within the company, underscoring its importance in everything they do. Amazon also emphasises giving customers choices, allowing them to pick their preferred models and providers. Amazon supports the idea of customers bringing their own large language models (LLMs) and hosting them on AWS, enhancing flexibility and control over data. The core belief of AWS is that data is the strongest asset of an organisation, irrespective of size or industry. That's why they ensure customers retain ownership of their data, a key point for responsible innovation and a contrast to practices at other big tech firms like Google and Microsoft, where data ownership isn't as emphasised. Additionally, AWS makes it a priority to define the boundaries within which AI operates, and has built guardrails so that AI models are not training themselves.

Organizational structure plays a role too, there have been major internal changes in reporting structures to better support responsible practices. Having the right reporting structure within the organisation is vital because we have a culture of insisting on the highest standards and disagreeing with the status quo where necessary. Having the right teams set up allows us to take escalations seriously and remain agile even as a large company. Another one of our company values is "disagree and commit", which allows employees to feel more comfortable to express their thoughts to leadership - positive and negative. From a leadership perspective, having the right manager to listen to these concerns allows AWS to listen to employees and

continue innovation at a rapid pace. The Individual contributors (i.e. not managers) are the ones closest to the customers, technology, and the field. Therefore it is important for them to have a voice. This is another part of our culture that allows us to innovate responsibly, because we take feedback from the field teams seriously.

Amazon also adopts a trial-and-error approach to define and refine regulations, aiming to set industry standards in cases where there are none formally defined.. For example, they adhere to and help shape security standards like the OWASP top 10, positioning themselves as both contributors to and early adopters of industry-wide standards.

Q: What allows you to succeed when considering the competitive landscape

AWS is a large multinational company with ample resources to expand its offerings to customers in all markets and regions, and has increased its sales by 29% year over year (YoY) to $80.1 billion according to the 2023 Gartner report, so there is still positive sentiment and significant growth in the market regardless of the fierce competition in the AI industry. AWS offers an extensive global cloud infrastructure. Its Availability Zones provide greater coverage than any of its competitors, and AWS makes it easy for customers to deploy their models across multiple Availability Zones. While AI is the primary focus for AWS as well as customers across the globe, it is worth noting that AWS has many strengths in cloud computing and other industries haven't stopped, other tech is still in progress and not falling because of AI.

However, AWS has altered some aspects of its strategy in response to the AI boom and other competitors, primarily OpenAI and Microsoft. Originally, the AWS strategy has always been to avoid speaking about competitors and focusing on how AWS's arsenal of products and services can be utilised to achieve the customer's end goals. However, since chatGPT disrupted the industry in 2022, competitors have increased direct product comparisons which has forced AWS to do the same, which is a new marketing strategy for the company. In short, AWS is more aware of its competitors, but still does not do feature by feature comparisons as a commitment to stick to its core values. Rather, AWS is sticking to its core principle of

identifying the customer problem and then "working backwards'' from it to come up with the best possible solution. One related shift is the internal acceptance of the multi-cloud approach by customers. A multicloud approach is when a customer has workloads deployed with various cloud providers instead of committing to one. This is typically done due to company regulatory policies or "picking and choosing" a provider for its core strengths; however, it can lead to increased costs and data connection issues. AWS is becoming more supportive of customers' multi cloud strategies as an update to their product strategy based on Gartner concerns that cloud portability is a focus for customers and an area where AWS can benefit from improvement.

Adding to this, Gartner places AWS as the highest ranked in terms of ability to execute, a testament to its robust operational capabilities and innovative solutions. In 2022, AWS introduced the AI Use Case Explorer that augments the AWS Solutions Library and aids solution architects to help customers and prospects select the right AI solutions tailored to their industry and business-specific needs. This introduction is part of a broader internal effort to educate AWS teams on where AI makes sense and to be responsible about the use cases, emphasising the practical application of AI in solving real-world problems. Historically, AWS spends less on marketing than Google and Microsoft, but it is now highlighting some of these gaps in messaging to better articulate its unique offerings and advantages in the marketplace.

Appendix E: AWS Data Analysis Table

First-Order Concepts (Specific Quotes)	Second-Order Themes	Aggregate Dimensions
Restructuring teams to focus on building in-house LLMs	Investing heavily in new technologies	Responsiveness to customer demands
Reporting structure shifted from area-based to industry-focused	Organisational shift	
Offering customers a choice of different Gen AI models rather than locking them into a proprietary model	Ignoring hype and tailoring services to use case	
Investing in generative AI and partnering with Anthropic	Use of partnerships to deliver products faster	
Focus on data security at every level of the business	Constraining speed of innovation with responsibility	Trustworthiness as a competitive advantage
Amazon has been a big supporter of open source projects	Engaging stakeholders with transparency	
Focus on improving explainability of opaque Gen AI models	Explaining potential harms to stakeholders	Acceptability of technology as a competitive advantage
Built-in guardrails so the model is not training itself or tuning itself on harmful behaviour.	Self-regulation in absence of formal governance	
Actively working with governments to formulate the 'right' regulations	Helping craft formal governance to cement market-position	

Q: Tell us about a significant innovation that has shaped the company in recent years

The core product of Airskin is the pressurised "skin" system for robots allowing for floor space to be saved and the creation of a more collaborative and productive manufacturing environment between robots and humans. This innovation, which originated from the Technical University of Vienna, consists of soft, pressure-sensitive safety pads mounted directly onto industrial robots and other automated machinery. This technology allows industrial robots to operate safely alongside humans without the need for traditional protective barriers, such as fences.

The introduction of AIRSKIN has changed the way industrial environments handle automation. By enabling fenceless operations, AIRSKIN drastically reduces the required floor space, enhances flexibility, and improves the overall efficiency of production lines. Robots equipped with AIRSKIN can perform tasks up to six times faster than traditional collaborative robots (cobots), while still maintaining high standards of safety, evidenced by their PL e, Cat. 3 / SIL 3 certifications.

Moreover, AIRSKIN extends its utility beyond just robots to Automated Guided Vehicles (AGVs), End-of-Arm Toolings (EoATs), and other moving machinery, facilitating a transformation toward open and flexible production environments. The ability of AIRSKIN to be integrated with major robotic systems like KUKA, FANUC, and Stäubli further enhances its applicability across various industrial industrys, offering tailored safety and operational solutions.

Airskin's strategy currently revolves around being the first to market in this sector and at this scale, their focus is on developing the best possible products to lower competition and retain the first mover advantage (Tarver, 2020) . This adaptation has not only enabled AIRSKIN to meet the current demands of the industry but also to set new standards and lead the way toward future developments in robotic automation.

Q: How does your company foster a culture that supports and drives responsible innovation strategies? Explain how you ensure they have the intended positive impacts.

AIRSKIN is committed to fostering a culture of responsible innovation that seamlessly integrates advanced safety technologies with operational efficiency. The company's strategy centres on the development of fenceless automation solutions, enabling human-robot interaction without the conventional barriers that traditionally separate them. This approach not only maximise floor space but also enhances the adaptability of production environments to various manufacturing needs, reflecting AIRSKIN's forward-thinking in industrial design.

The innovation culture at AIRSKIN is also characterised by its proactive engagement with emerging market trends and technological advancements. The introduction of the AIRSKIN technology, a soft, pressure-sensitive skin that transforms standard industrial robots into collaborative robots (cobots), exemplifies the company's ability to respond innovatively to industry demands. This technology allows robots to detect human presence and adjust their operations accordingly, ensuring safety while maintaining high efficiency.

Additionally, AIRSKIN places a strong emphasis on customisation and flexibility, recognizing that one-size-fits-all solutions are often not feasible in the diverse field of industrial automation. The company's modular product offerings, such as AIRSKIN pads for different robot models and applications, support this philosophy by providing tailored solutions that meet specific customer needs.

To ensure these innovations have the intended positive impacts, AIRSKIN conducts thorough risk assessments and safety evaluations as part of their development process. These assessments ensure that each new product not only meets regulatory safety standards but also aligns with the company's commitment to delivering safe and effective automation solutions. By integrating these practices into its innovation process, AIRSKIN reinforces its role as a leader in responsible industrial automation.

Q: What allows you to succeed when considering the competitive landscape

Airskin exemplifies responsible innovation through its commitment to enhancing workplace safety. The development of the Airskin pads reflects a proactive approach to safety challenges in industrial automation. By mitigating the risks of injury, Airskin not only protects workers but also helps companies comply with stringent safety regulations and standards. This is particularly important as governments and international bodies are continuously updating safety guidelines to keep pace with technological advancements.

Ambition to move airskin to everything that moves e.g. linear production lines allows Airskin to have the first mover advantage (Lieberman & Montgomery, 1988), as more competitors inevitably arise to rival Airskin. The flexibility and adaptability of AIRSKIN technology also contribute significantly to its success. The modular nature of the AIRSKIN pads allows them to be customised and applied to a wide range of robot models and other automated machinery, making them versatile for different industrial applications. This adaptability is crucial in an industry where the needs and configurations of production facilities can vary greatly.

AIRSKIN's strategy also includes a strong focus on partnerships and collaborations. By working closely with leading robot manufacturers and integrating their feedback into product development, AIRSKIN ensures that its offerings are closely aligned with the latest trends and customer demands in the automation industry.

AIRSKIN's global outreach, with applications installed in over 40 countries, allows it to gain diverse insights and maintain a broad market presence. This global perspective enables AIRSKIN to anticipate and respond to the varying needs of international customers, further strengthening its position in the competitive landscape.

Moreover, AIRSKIN commits to maintaining a high level of safety by offering comprehensive training programs to their partners. These training initiatives are designed to ensure that all parties involved in the deployment and operation of AIRSKIN-equipped

systems are well-versed in best practices for safety and efficiency. This not only fortifies the reliability and effectiveness of their products but also reinforces AIRSKIN's reputation as a leader in safe industrial automation solutions.

Appendix G: Airskin Data Analysis Table

Order Concepts	2nd Order Themes	Aggregate Dimensions
"A partnership where we equipped collaborative robots with our soft skin technology."	Leveraging Strategic Partnerships	Collaboration and Partnerships
"Clients had issues with collaborative robots being sustainable and safe in industrial environments."	Solving Industry-Specific Problems	Addressing Ethical and Social Concerns
"We already have this technology to equip industrial robots with our soft skin."	Proactive Technological Advancement	Advocating for Technology
"Unleashing the full potential of industrial robots by ensuring maximum payloads and maintaining industrial robustness."	Optimising Operational Efficiency	Efficiency and Performance
"The evolution from fully automated production without humans to needing human presence for service and maintenance."	Adapting to Hybrid Human-Robot Operations	Adaptability and Flexibility

"Developing flexible production systems that are easy to rearrange and open for human-robot interaction."	Creating Flexible and customisable Solutions	customisation and Flexibility
"We offer the highest safety performance level, meeting ISO 13849 standards."	Ensuring High Safety Compliance	Trust in Company Operations
"Our solutions are adaptable to various robot brands and models, such as KUKA and Yaskawa."	Ensuring Cross-Platform Compatibility	Acceptability of Technology
"We provide modular safety and adaptability to specific gripper configurations."	Developing Modular and Scalable Safety Solutions	Trust in Company Operations
"We create safety concepts and perform risk assessments to ensure fenceless and safe operations."	Implementing Comprehensive Risk Management	Risk Management and Mitigation