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Review

Tech Giants' Responsible Innovation and Technology Strategy: An International Policy Review

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Abstract: As digital technology continues to evolve rapidly and get integrated into various aspects of our cities and societies, the alignment of technological advancements with societal values becomes paramount. The evolving socio-technical landscape has prompted an increased focus on responsible innovation and technology (RIT) among technology companies, driven by mounting public scrutiny, regulatory pressure, and concerns about reputation and long-term sustainability. This study contributes to the ongoing discourse on responsible practices by conducting a policy review that delves into insights from the most influential high-tech companies'—so-called tech giants'—RIT guidance. The findings disclose that (a) leading high-tech companies have started to focus on RIT; (b) the main RIT policy focus of the leading high-tech companies is artificial intelligence; (c) trustworthiness and acceptability of technology are the most common policy areas; (d) affordability related to technology outcomes and adoption is almost absent from the policy; and (e) sustainability considerations are rarely part of the RIT policy, but are included in annual corporate reporting. Additionally, this paper proposes a RIT assessment framework that integrates views from the policy community, academia, and the industry and can be used for evaluating how well high-tech companies adhere to RIT practices. The knowledge assembled in this study is instrumental in advancing RIT practices, ultimately contributing to technology-driven cities and societies that prioritise human and social well-being.

Keywords: responsible innovation; responsible innovation and technology; responsible AI; social responsibility; artificial intelligence; science and technology policy; high-tech companies; tech giants

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1. Introduction

Against the backdrop of ever-changing and exponentially advancing science and technology, along with digital transformation pressures on our institutions, many people are worried about the undesired effects of unparallelled technological developments [1,2]. These technological advances are not only shaping our cities to be digital and smart but also significantly affecting our society [3–5]. While the advancements are undeniably groundbreaking, particularly developments in artificial intelligence (AI) field, they introduce multiple potential futures and uncertainties [6–9].

The inherent complexity of innovation practices has sparked broader discussions about their alignment with societal values, ethical standards, and collective aspirations, especially concerning disruptive innovations and technologies [10–12]. As advanced digital technologies increasingly permeate into our daily lives, it is imperative to ensure that their development trajectories address not only economic or functional objectives but also uphold societal values, demonstrate ethical integrity, and promote long-term sustainability [13–15].

Amid growing concerns regarding aligning technological achievements with societal needs, the dialogue around 'responsible innovation and technology' (RIT) has gained

increasing attention recently [16–18]. Such dialogue emphasises that modern innovation practice should deliver responsible technological outcomes and ensure these outcomes can be rationally integrated into our cities and societies, thereby mitigating potential repercussions of contemporary technological leaps [19–22]. As the major actors in innovation practices, technology companies, especially those with global influence, find themselves at the nexus of this transformative dialogue [23,24]. They realise that adopting a responsible approach in the innovation process is not only beneficial for society but also crucial for maintaining a positive brand image and securing long-term success in an ever-changing market [25–27]. As stakeholders demand greater accountability and consumers seek out ethically sound products and services, the RIT concept has become a key driver in guiding corporates' future technological development direction [10,28–31].

Although the interest of academia and the policy community in RIT is growing, and some effort has been put into RIT practices, research from the business community's perspective remains limited [10,32]. Existing research and discussion regarding 'responsibility' in the business setting are more concerned with widely recognised concepts such as 'corporate social responsibility' (CSR) and 'corporate sustainability' (CS) [23–25,33]. However, research focused on corporates' specific insights into the RIT concept remains relatively underexplored. Although RIT, CSR, and CS are all concepts that can be used to address the ethical, social, and environmental responsibilities of businesses, each concept has its unique emphasis.

RIT is distinct in its focus on innovation practices, ensuring that new products, services, or technologies are developed and introduced responsibly [32,34]. On the other hand, CSR and CS have broader scopes, addressing the wider social and environmental responsibilities and sustainability of businesses, respectively [35–38]. As RIT practices continue to be launched by leading high-tech companies, additional investigations and reviews are needed to capture the growing knowledge on RIT from corporations' perspective. This will help bridge the research gap and may contribute to making the concept more responsive and adaptable to real-world scenarios.

In addressing this gap, the paper at hand conducts a comprehensive policy review to investigate insights into RIT from the top 100 global high-tech companies (ranked by market capitalisation)—so-called tech giants. This study aims to clarify companies' guidance on integrating the RIT concept into their innovation practices. Accordingly, the following research question was posed in this paper: How do technology companies guide their products and services to respond to the concept of responsible innovation and technology (RIT)? The findings of this paper contribute to a richer understanding of how these highly innovative and successful technology companies interpret and enact the RIT concept in their innovative pursuits. By synthesising insights from technology companies, this paper provides valuable insights for academic and industry stakeholders as well as social stakeholders, e.g., customers and local communities, to practically foster more responsible and socially beneficial technological outcomes.

This paper's key contribution is that it develops an indicative framework based on corporate insights and established viewpoints from the policy community and academia. Unlike previous approaches, this covers a comprehensive range of considerations essential for responsible innovation and technology. This framework provides a systematic approach to holistically evaluate technological outcomes against a broad spectrum of responsible innovation principles. By transforming an abstract concept into specific objectives and statements, the framework operationalises the goals of RIT, making them more actionable and measurable within organisations.

2. Literature Background

The dialogue around RIT originated in the European research and innovation (R&I) policy—the Horizon 2020 framework program [39,40]. Since this concept earned a prominent position in policy spheres, the policy community have begun to emphasise that the modern innovation process should be open, interactive, and transparent [13,41,42]. This

approach enables social actors to participate in the innovation process and share the responsibilities with innovation actors to shape responsible innovation and technology, aiming to ensure the technological outcomes can both meet societal needs and address the potential or unanticipated social impacts and challenges that accompany them [16,19,43,44]. To this end, European Commission officer Rene von Schomberg preliminarily proposed specific criteria to elucidate the somewhat abstract notion of RIT, which encompasses 'ethically acceptable', 'sustainable', and 'societal desirable' [44].

On this basis, Li et al. [22] (p. 1) further identified the key characteristics of RIT from an academic perspective, which they defined as 'acceptable', 'accessible', 'aligned', 'trustworthy', and 'well governed'. The authors emphasised that "*RIT should deliver acceptable, accessible, trustworthy, and well governed technological outcomes, while ensuring these outcomes are aligned with societal desirability and human values and should also be responsibly integrated into our cities and societies*". Moreover, to clarify these characteristics in greater detail, the authors provided detailed descriptions for each characteristic. For example, they explained that the 'acceptable' characteristic covers the 'ethical', 'equitable', and 'harmless' aspects. Their study provides a conceptual framework of RIT design and implementation, assisting innovation actors, policymakers, and social stakeholders to ensure emerging innovations and technologies are more 'responsible'.

It is noteworthy that commercialisation is a pivotal phase in innovation, and most innovations are founded and produced by the private sector [23,45]. With growing interest in the theme of 'being responsible' in technospheres, some influential technology companies have embraced the RIT concept to respond to societal needs and challenges by creating responsible products and services [24,28,46]. These companies have established various principles based on their own perspectives, missions, or specific business backgrounds to help guide their product and services to respond to the concept of RIT, e.g., Microsoft's *Responsible AI*, Amazon's *Responsible Use of Machine Learning*, Samsung's *Responsible Production and Sales*, and Atlassian's *Responsible Technology*.

RIT in a business context refers to the emerging concept where businesses actively consider the broader societal, ethical, and environmental implications of their innovations and technological deployments [10,23,47]. Li et al. [24] and Jarmai [48] posited that the impetus for corporates to adopt a responsible approach in their innovation process primarily stems from both internal factors, such as company vision and the pursuits of key individuals, and external factors, including market demand, policy pressure, and the expectations of civil society. Some studies indicated that incorporating the RIT concept into business strategies contributes to leading long-term benefits, including enhanced brand reputation, increased trust among consumers and stakeholders, and a more sustainable and resilient business model [27,49–51].

Nonetheless, Boenink and Kudina [15] pointed out that the interpretations of RIT characteristics are not universal and eternal but vary by region, time, or other specific factors. The characteristics appreciated by academia and the policy community may be disliked or overlooked by industry or consumer groups, and vice versa [10,23].

Against this backdrop, this paper undertakes a policy review supported by the previous research efforts. The aim of this study is to glean complementary insights about RIT from a corporate perspective and to integrate existing views from the high-tech policy community and academia, ultimately attempting to formulate a comprehensive and implementable RIT framework.

3. Methodology

This paper concentrates on addressing the following research question: How do technology companies guide their products and services to respond to the concept of responsible innovation and technology (RIT)? To address this, this study conducts a policy analysis, defined by the Centers for Disease Control and Prevention (CDC) [52] as "*the process of identifying potential policy options that could address the problem and then comparing those options to choose the most effective, efficient, and feasible ones*".

To conduct a policy analysis, this study adopts a qualitative and quantitative thematic analysis of corporate documents using the NVivo software (v.14). Content analysis of corporate documents has been highly praised in previous academic papers as a promising approach to understanding corporate practices [53]. Despite NVivo being renowned for analysing the contents of interviews, increasing studies have used it as a tool for content analysis of documentation, e.g., corporate social responsibility (CSR)-related reporting documents [53], strategy documents of local governments [54], and healthcare planning documents [55].

Different from previous content analysis studies, this paper applies a targeted search strategy to identify RIT-related documents that are publicly accessible and written in English by searching via the internal search engine of corporations' official websites. In addition, for those websites without internal search engines or displaying ambiguous RIT-related content, we conducted complementary search tasks through the Google search engine to ensure the comprehensiveness of our database. In some search results, content that does not provide clear information, leaves room for multiple interpretations, omits crucial details necessary for a comprehensive understanding, makes broad statements without specifics, or presents information without the necessary context is identified as ambiguous content.

The list of technology companies selected for this purpose was sourced from CompaniesMarketCap [56], which offers a daily updated global ranking of technology companies by market capitalisation (https://companiesmarketcap.com/tech/largest-tech-companies-by-market-cap (accessed on 1 December 2023). The reliability of this website has been verified by numerous organisations in the public and private sectors, and the data provided have been incorporated into their official reports [57–59]. The query string of the search task included a fuzzy format '*' to assure further the comprehensiveness of the obtained data, which was determined as follows: ('innovation' OR 'technolog*') AND ('responsible' OR 'ethic*' OR 'explainable' OR 'trust*' OR 'transparen*'). Figure 1 shows the specifics of the corporate document selection process.

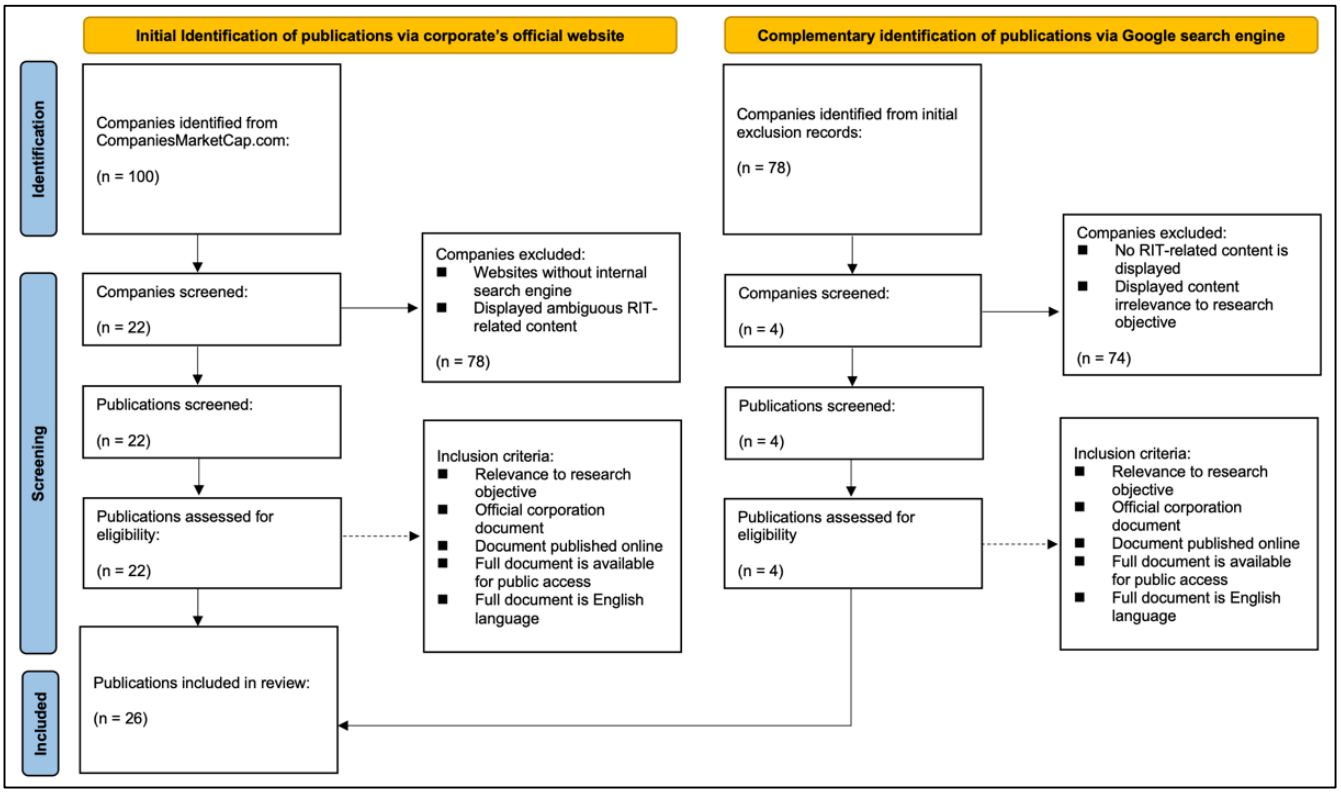

Figure 1. Policy document selection process.

The search results show that, out of the top 100 global technology companies by market capitalisation, 26 companies provide RIT-related documents that are publicly accessible online. These documents include corporate reporting, website content, official blog posts, and internal policies and guidelines. Table 1 provides a brief profile of these companies.

Table 1. Profiles of the case companies.

Company	Region	Profile
Microsoft	USA	Microsoft is a technology company specialising in software, hardware, cloud services, and digital solutions, driving innovation in numerous sectors, from computing to business applications.
Alphabet (Google)	USA	Alphabet is the parent company of Google, focusing on search, advertising, cloud computing, AI, and digital services, with ventures in healthcare, autonomous vehicles, and other technological innovations.
Amazon	USA	Amazon is an e-commerce company providing cloud services via AWS, streaming with Prime Video, and branching into AI, devices, and retail, driving transformative consumer and business solutions.
NVIDIA	USA	NVIDIA is a technology company renowned for its graphics processing units (GPUs) for gaming, also venturing into AI, deep learning, automotive AI solutions, and data centre advancements.
Meta (Facebook)	USA	Meta Platforms, formerly Facebook, focuses on social media services, augmented and virtual reality, advertising, and digital communication tools, aspiring to build a comprehensive metaverse for global users.
Samsung	Republic of Korea	Samsung is an electronics company specialising in smartphones, TVs, semiconductors, and home appliances, while also venturing into software, digital services, and cutting-edge technology innovations.
Oracle	USA	Oracle is a technology company specialising in database software, cloud solutions, enterprise software products, and hardware systems, serving businesses with integrated technology stacks.
Adobe	USA	Adobe is a software company known for creative and multimedia solutions, digital marketing tools, and document management, driving digital content creation and optimisation across platforms.
Salesforce	USA	Salesforce is a cloud-based software company specialising in customer relationship management (CRM) solutions and offering a suite of enterprise applications for marketing, sales, service, and analytics.
Cisco	USA	Cisco is a technology company focusing on networking hardware, software, telecommunications equipment, and cybersecurity solutions, enabling seamless connectivity and digital transformation for businesses.
Intel	USA	Intel is a semiconductor manufacturer specialising in microprocessors, chipsets, and integrated solutions, driving advancements in computing, data centres, AI, and broader technology ecosystems.
Qualcomm	USA	Qualcomm is a semiconductor manufacturer specialising in wireless technology innovations, designing chips for smartphones, and pioneering advances in 5G, IoT, and AI across various platforms.
IBM	USA	IBM is a technology company focusing on cloud computing, AI, enterprise software, and hardware, offering integrative business solutions and IT consultancy.
Sony	Japan	Sony is an electronics company specialising in electronics, entertainment, gaming (PlayStation), music, film production, and professional broadcasting solutions, driving innovation in media and consumer technologies.
Schneider Electric	France	Schneider Electric is a global specialist in energy management and automation, offering solutions for homes, buildings, data centres, infrastructure, and industries, driving sustainable and integrated efficiency.
Automatic Data Processing	USA	Automatic Data Processing (ADP) is a global provider specialising in human capital management solutions, offering payroll, tax, HR services, and analytics to businesses of varying sizes.

Table 1. *Cont.*

Company	Region	Profile
Airbnb	USA	Airbnb is a global online platform connecting travellers with hosts, specialising in unique accommodations, experiences, and evolving into travel services, redefining how people experience new destinations.
Equinix	USA	Equinix is a technology company specialising in data centre services, connecting businesses to their customers and partners inside interconnected data centres, driving digital business performance through platform solutions.
VMware	USA	VMware is a software company specialising in cloud infrastructure, virtualisation, networking, security, and digital workspace technology, empowering businesses with integrated IT solutions for modern computing.
Workday	USA	Workday is a cloud-based software provider focusing on human capital management, financial management, and enterprise planning, offering adaptive solutions for business insights and growth.
Baidu	China	Baidu is a technology company specialising in internet services, AI research, autonomous driving, and digital advertising, often referred to as China's premier search engine platform.
NXP Semiconductors	The Netherlands	NXP Semiconductors is a technology company specialising in secure connectivity solutions for embedded applications, driving innovations in automotive, industrial, and IoT markets.
Atlassian	Australia	Atlassian is a software company providing collaboration and productivity tools for teams, including Jira, Confluence, and Bitbucket, serving developers and businesses to enhance workflow and project management.
Dell	USA	Dell is a technology company specialising in personal computers, servers, storage solutions, and network devices, also offering software and IT services to drive digital transformation for businesses.
Xiaomi	China	Xiaomi is an electronics company, known for smartphones, smart home devices, and IoT products, emphasising innovative technology, design, and cost-effective solutions for a connected lifestyle.
Palantir	USA	Palantir is a software company specialising in big data analytics, offering platforms for data integration, decision-making, and operational intelligence, serving government agencies and private sectors.

After identifying companies that have directly included RIT-related documents on their websites, we downloaded and saved all the documents (n = 26) that were highly relevant to our research objectives from their official websites and uploaded them to NVivo. To accurately address the research question, we established five nodes (acceptability goals, accessibility goals, alignment goals, trustworthiness goals, and well-governance goals) and fifteen sub-nodes drawing from Li et al. [22], who conducted a specific analysis of the corporate's RIT guidelines. In addition, to ensure the conceptual framework developed by Li et al. [22] is suitable for this study, we made necessary improvements to the node establishment work, e.g., modifying titles and keywords and clarifying specific content categories. Table 2 lists the nodes and the associated sub-nodes for each analysis task.

Table 2. Coding of the corporate document data.

Node	Sub-Node
Acceptability Goals	Equitability considerations, Ethics considerations, Harmlessness considerations
Accessibility Goals	Adaptability considerations, Affordability considerations, Inclusiveness considerations
Alignment Goals	Deliberateness considerations, Meaningfulness considerations, Sustainability considerations
Trustworthiness Goals	Explainability considerations, Security considerations, Transparency considerations
Well-governance Goals	Accountability considerations, Participation considerations, Regulatory considerations

4. Results

4.1. Quantitative Content Analysis

Corporate document data underwent rigorous analysis using NVivo (v.14). Word clouds visualised word frequency, with larger font sizes indicating a higher recurrence in corporate documents, enabling a concise representation of key thematic areas. Figure 2 displays word frequency across 26 corporations' RIT guidance documents, whereas Figure 3 showcases word frequency within the specifically coded segments. The visualisation results revealed that corporations' RIT guidelines predominantly pertain to AI. This emphasis likely stems from concerns regarding AI's profound potential to transform various sectors [60], coupled with ethical dilemmas related to 'black box' decision-making [61], inherent biases during model training [62], and data privacy issues regarding model construction [63].

Figure 2. Word frequency in document content.

Figure 3. Word frequency in the coding.

Given AI's vast potential and the range of associated challenges, these leading technology companies are endeavouring to embrace RIT concepts to navigate the transformative impact of AI technology in our cities and societies [64,65]. For instance, these companies emphasise enhancing the explainability and transparency of AI systems [66–68]. They also prioritise embedding human-in-the-loop mechanisms, striking a balance between efficiency and ethical considerations [69–71]. Furthermore, there's a concerted effort to integrate robust privacy and security measures into AI-driven practices and applications [72–74]. These views also coincide with those emphasised by the academic community [75–77]. Notably, keywords linked to these measures frequently appear in their RIT guidelines, as illustrated in Figure 3, e.g., explainable, privacy, security, transparency, control, oversight, and others.

Table 3 lists the analysed nodes, sub-nodes, number of sub-nodes mentioned within the guidance documents, sub-node frequency, and total frequencies. Figure 4 presents a hierarchy chart to visualise the information and data in Table 4. Within the same colour setting, larger rectangles (nodes) represent major themes. Smaller rectangles (sub-nodes) within larger rectangles (nodes) represent sub-categories of the larger theme. The size of each rectangle indicates the volume of instances coded to that node, with larger rectangles indicating a greater volume of instances.

Table 3. List of nodes, sub-nodes, and mention frequencies.

Node	Sub-Node	Sub-Nodes Mentioned in Policy Documents	Frequency of Sub-Node	Total Frequency Sub-Node
Acceptability Goals	Equitability considerations	20	20	51
	Ethics considerations	18	24	
	Harmlessness considerations	7	7	
Accessibility Goals	Adaptability considerations	11	14	31
	Affordability considerations	2	2	
	Inclusiveness considerations	13	15	
Alignment Goals	Deliberateness considerations	8	9	33
	Meaningfulness considerations	13	18	
	Sustainability considerations	6	6	
Trustworthiness Goals	Explainability considerations	15	15	65
	Security considerations	22	33	
	Transparency considerations	15	17	
Well-governance Goals	Accountability considerations	13	16	33
	Participation considerations	8	8	
	Regulatory considerations	9	9	

Table 4. Objectives of equitability considerations.

Equitability Considerations		
Objectives		**Statements**
OBJ 1	Avoid bias	Does not create, reinforce, or propagate harmful or unfair biases in all stages of innovation and technology practice, from design to deployment and beyond.
OBJ 2	Guard against discrimination	Upholds the rights of all individuals and groups, embraces the full spectrum of social diversity, and actively prevents any form of discrimination.
OBJ 3	Strive for fairness	Proactively identifies and eliminates obstacles to ensure fair treatment for all and empower every individual equally through innovation and technology.

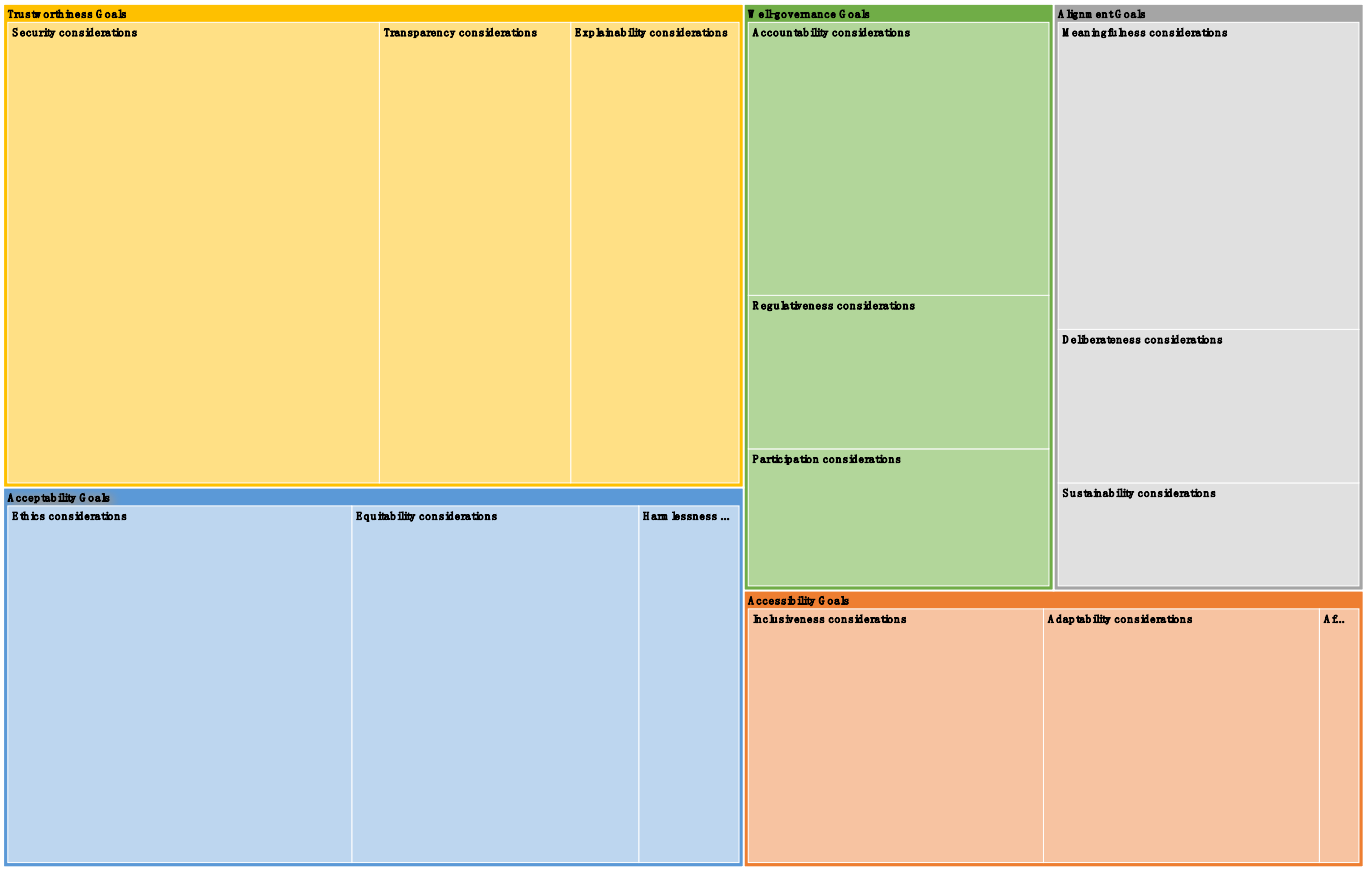

Figure 4. Hierarchy of nodes and sub-nodes.

In Figure 4, there are five nodes representing five primary areas of focus for technology companies: trustworthiness goals, well-governance goals, alignment goals, acceptability goals, and accessibility goals. For each node, there are sub-nodes that represent specific considerations, e.g., security, transparency, and explainability within trustworthiness goals. Of the five nodes, the two with the highest total sub-node frequencies were 'trustworthiness goals' (n = 65) and 'acceptability goals' (n = 51). The other three nodes had nearly identical levels of total sub-node frequencies: 'alignment goals' (n = 33), 'well-governance goals' (n = 33), and 'accessibility goals' (n = 31). Among the fifteen sub-nodes, 'security considerations' (n = 33) were most frequently mentioned, followed by 'ethics considerations' (n = 24). These findings suggest that these technology companies may place greater emphasis on security and ethics matters in their RIT guidance formulation. The reason might be that these companies want their products and solutions to be trustworthy so as not to jeopardise their own business while gaining more public trust and acceptance.

Additionally, they may be willing to adhere to ethical practices within the nature of the company [78–80]. In addition, external factors might also be one of the reasons why technology companies emphasise these aspects when formulating guidance documents, e.g., public concerns and sentiment [81], regulatory pressure [82], and ethical considerations [83]. Significantly, 'affordability considerations' (n = 2) are mentioned notably less than other individual sub-nodes (average n = 14). This reflects that there may be differing priorities among the policy community, academia, and industry in developing RIT guidelines based on their respective perspectives [10,23].

4.2. Qualitative Content Analysis

After conducting the quantitative analysis, we transitioned to an in-depth qualitative content analysis. Based on the findings, this paper emphasises that within the context of responsible innovation, all our innovation initiatives should target the goals of accept-

ability, accessibility, alignment, trustworthiness, and well-governance for technological outcomes. By integrating insights from the investigated companies, we spotlight fifteen pivotal considerations (three for each goal) that merit attention during their innovation practices. Moreover, we further delineate more specific objectives (three for each consideration) under each consideration, aiming to furnish clearer guidance for evaluating whether the technology and its marketable products and services are responsible. Comprehensive findings from this analysis are detailed in the subsequent section, providing solid evidence of the developed assessment framework. Figure 5 presents a conceptual RIT assessment framework, and the full assessment framework is provided in Appendix A Table A1.

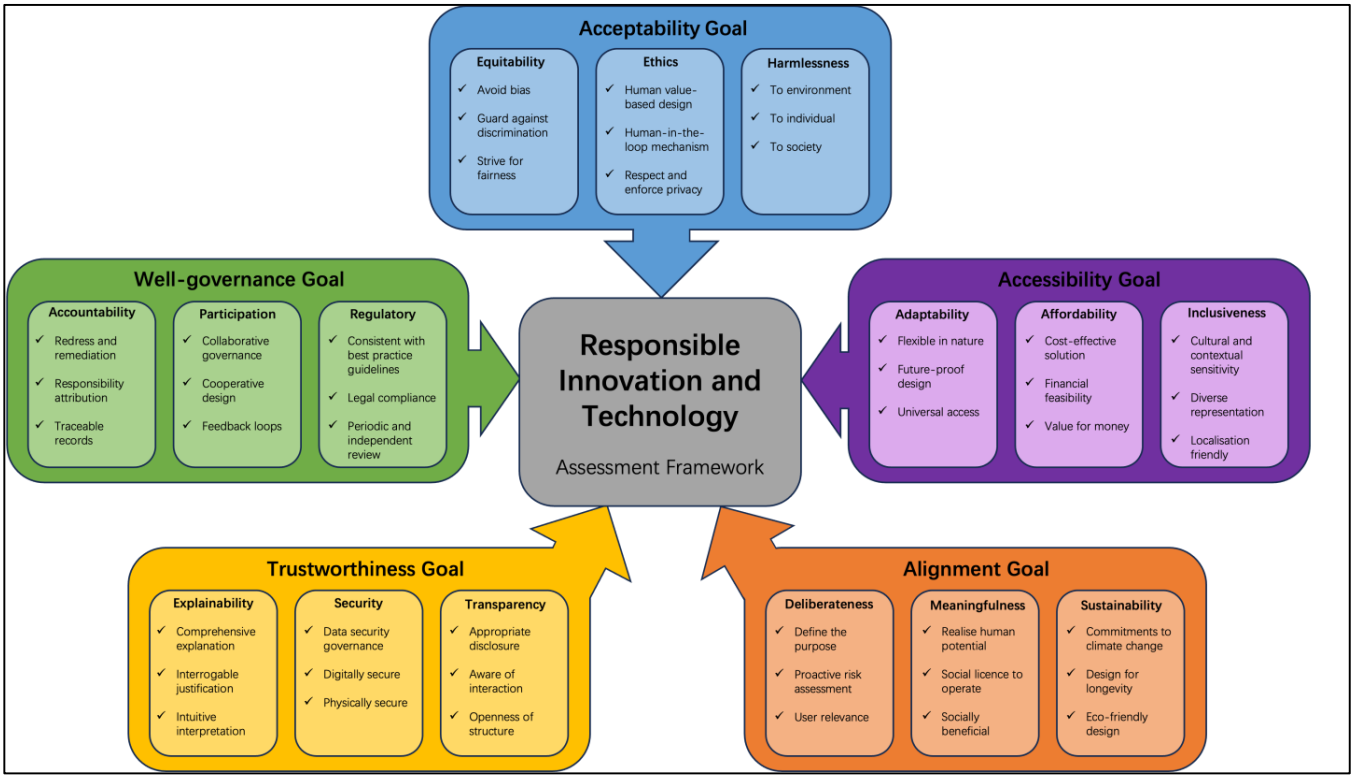

Figure 5. Conceptual RIT assessment framework.

4.2.1. Acceptability Goals

The insights gleaned from the 'acceptability goals' category highlighted the key considerations that technology companies emphasise to ensure that their technologies, products, or services can be accepted by users, stakeholders, and society at large. The most noticeable considerations linked to acceptability goals in RIT guidelines fell under the following categories: (a) equitability; (b) ethics; and (c) harmlessness.

Equitability Considerations

Oracle [68] indicated that AI systems can potentially reinforce or even exacerbate existing biases inherent in their training data. Such a magnification of biases can result in discriminatory effects, potentially restricting some individuals from accessing specific opportunities or services:

> *"AI systems can perpetuate and even amplify biases present in the data used to train them. This bias can lead to discriminatory outcomes, such as denying certain individuals access to opportunities or services".*

Adobe [84] highlighted the necessity for meticulous attention to bias, especially when a product or service could profoundly influence facets of an individual's life:

> "*We understand that special care must be taken to address bias if a product or service will have a significant impact on an individual's life, such as with employment, housing, credit, and health*".

Google [74] emphasised the importance of preventing adverse effects on individuals from AI applications, especially those tied to sensitive attributes:

> "*Avoiding unjust impacts on people, particularly those related to sensitive characteristics such as race, ethnicity, gender, nationality, income, sexual orientation, ability and political or religious belief*".

Moreover, Sony [85] stated that when using AI, the diversity and human rights of all stakeholders should be upheld while ensuring non-discrimination:

> "*In its utilization of AI, Sony will respect diversity and human rights of its customers and other stakeholders without any discrimination while striving to contribute to the resolution of social problems through its activities in its own and related industries*".

And VMware [86] advocated for the fair treatment of all individuals by AI, irrespective of race, gender, disabilities, income, or any other diversity markers:

> "*It is critical to invest stringent effort to identify such bias to avoid unfair and improper behavior from AI systems. Regardless of race, gender, disabilities, income, and any other indicator of diversity, all people should be treated fairly by AI systems*".

Atlassian [87] espoused similar views and expressed a desire for organisations and technologies to embody openness, inclusivity, fairness, and justice, mirroring human-centric values and inherent basic human rights:

> "*We want our company and our technologies to be open, inclusive, fair and just: to reflect the human-centric values and fundamental human rights that we all share*".

Thus, this paper emphasises that 'technology and its marketable products and services' (collectively referred to as 'TMPSs' in this paper) should neither introduce nor amplify harmful biases, from design to deployment. TMPSs should uphold the rights of all individuals, respect social diversity, counter discrimination, and proactively eliminate barriers to guarantee fair treatment and empowerment for everyone. Table 4 presents our recommendations for specific objectives and statements within the context of equitability considerations.

Ethics Considerations

Oracle [68] stated that with the progression of AI technology, there is a possibility these systems could function autonomously and make independent decisions. Such advancements usher in concerns about accountability for these systems' actions and the need to guarantee their alignment with human ethics and values:

> "*As AI systems become more advanced, they may be able to operate independently and make decisions on their own. This potential development raises questions about who is responsible for the actions of these systems and how to ensure they align with human values*".

Moreover, Cisco [73] highlighted that AI applications frequently utilise personal data, which could pose threats to individual privacy and civil rights if not handled appropriately:

> "*Applications of AI often use personal data that could impact individual privacy and civil liberties if not managed properly*".

Further, NXP Semiconductors [70] emphasised the crucial role of ethics in AI system design and development. They pointed out that an approach driven solely by technological advancement might overlook human needs:

> "*As designers and developers of AI systems, it is an imperative to understand the ethical considerations of our work. A technology-centric focus that solely revolves around improving the capabilities of an intelligent system doesn't sufficiently consider human*

needs. By empowering our designers and developers to make ethical decisions throughout all development stages, we ensure that they never work in a vacuum and always stay in tune with users' needs and concerns".

Schneider Electric [88] denoted that adhering to ethics and compliance is the foremost principle in the AI and data science development process. This can be achieved by adopting a human-centred approach and a vigilant oversight mechanism:

"*The number one rule we apply when developing AI and data science is ethics and compliance in line with our Trust Charter. We leverage digital technologies for a sustainable future based on human-centered design with a 'do no harm' oversight*".

IBM [66] emphasised that users should maintain control over their data and their applications. They explain that it is the duty of innovation teams to ensure users remain in control of their data and interactions. As AI technology advances, organisations must uphold ethical standards, using AI to enhance, not diminish, individual privacy:

"*Preserve and fortify users' power over their own data and its uses*". "*It's your team's responsibility to keep users empowered with control over their interactions and data*". "*Organizations have a responsibility to use AI ethically as the technology matures. AI should be used to amplify our privacy, rather than undermine it*".

NXP Semiconductors [70] summarised their stance on AI, stating that AI systems must respect human autonomy and ensure individuals are not subjugated or coerced by them. While there is an acknowledgment of humans ceding some decision-making to machines, the balance of power should always favour humans. It is essential to retain control and ensure AI aligns with privacy standards:

"*AI systems should preserve the autonomy of human beings and warrant freedom from subordination to—or coercion by—AI systems. The conscious act to employ AI and its smart agency, while ceding some of our decision-making power to machines, should always remain under human control, so as to achieve a balance between the decision-making power we retain for ourselves and that which we delegate to artificial agents as well as ensure compliance with privacy principles*".

Workday [71] suggested the adoption of a human-in-the-loop strategy, ensuring that end-users have control over the final decisions:

"*We focus on improving and developing people's capabilities and experiences and leverage a 'human-in-the-loop' approach to enable end-user control over ultimate decisions*".

Thus, this paper emphasises that TMPSs should prioritise human values and morals during their design process, embed human oversight in decision-making to balance efficiency with ethics, and consistently incorporate privacy principles throughout their entire lifecycle to safeguard user privacy. Table 5 presents our recommendations for specific objectives and statements within the context of ethics considerations.

Table 5. Objectives of ethics considerations.

Ethics Considerations		
Objectives		**Statements**
OBJ 4	Human value-based design	Prioritises human values and morals in the innovation process, ensuring that technological outcomes meet functional requirements and align with broader ethical and societal norms.
OBJ 5	Human-in-the-loop mechanism	Embeds appropriate human oversight and intervention into decision-making processes to balance efficiency with ethical considerations.
OBJ 6	Respect and enforce privacy	Incorporates privacy principles at every stage of the innovation lifecycle, ensuring that innovation and technological outcomes consistently prioritise and protect user privacy.

Harmlessness Considerations

NVIDIA [89] highlighted the importance of minimising potential harm arising from the deployment of AI models or systems. For example, the proliferation of AI in various sectors can inadvertently erode essential human skills due to increased automation, potentially leaving individuals ill-equipped without AI assistance. This surge in AI-driven changes can also catalyse economic and social disruptions, with industries transforming rapidly and possibly igniting social unrest if not navigated judiciously:

> "*NVIDIA aims to reduce the risk of harm from deployment of AI models or systems*".

Google [74] espoused similar views and have committed to actions based on their core principle of being harmless to limit applications that might be harmful or abusive:

> "*Be made available for uses that accord with these principles: We will work to limit potentially harmful or abusive applications*".

From an environmental perspective, Qualcomm [90] places a premium on environmental concerns. Not only do they have specific objectives for reducing water withdrawal, but they also emphasise sustainable product design. Their aim to mitigate risks to the environment and fortify the resilience of their supply chains:

> "*We want our products to be distinguished not only by their capabilities but also by the care and attention we put into producing them*".

From a societal perspective, Oracle [68] stated that AI has the potential to automate numerous tasks, leading to job loss issues. Consequently, there are rising concerns about the support and measures required for workers and communities impacted by these technological shifts:

> "*AI can automate many tasks and processes, which can lead to job displacement. This displacement raises concerns about how to support workers and communities affected by these changes*".

Hence, Xiaomi [72] emphasised that their goal is to offer users AI products and services that are both safe and dependable, ensuring no harm comes to society:

> "*Xiaomi is firmly dedicated to ensuring security and safety throughout development and application of trustworthy AI technologies, providing users with safe and trustworthy AI products and services and making sure that our trustworthy AI will not do any harm to society*".

In addition, NXP Semiconductors [70] indicated that AI systems must be designed to prioritise the well-being of humans, ensuring they do not jeopardise individuals, whether in societal or work environments:

> "*AI systems should not harm human beings. By design, AI building blocks should protect the dignity, integrity, liberty, privacy, safety, and security of human beings in society and at work. Human well-being should be the desired outcome in all system designs*".

Thus, this paper emphasises that TMPSs should ensure respect and protection of the environment, prevent any harm to individuals, both physical and psychological, and guarantee that negative impacts on society are minimised while fostering harmony between technology and societal progress. Table 6 presents our recommendations for specific objectives and statements within the context of harmlessness considerations.

Table 6. Objectives of harmlessness considerations.

Harmlessness Considerations		
Objectives		**Statements**
OBJ 7	Harmless to environment	Ensures respect and protection of the environment, avoiding practices that lead to environmental degradation or the corruption of natural resources.
OBJ 8	Harmless to individual	Does not lead to any harm against any individuals, including physical and psychological harm.
OBJ 9	Harmless to society	Minimises adverse impacts on society and commits to the harmonious progress of technology and society.

4.2.2. Accessibility Goals

The insights gleaned from the 'accessibility goals' category highlight the key considerations that technology companies emphasise to ensure that their technologies, products, or services are accessible to as many people as possible, making sure no one is left behind in the digital age. The most noticeable considerations linked to accessibility goals in RIT guidelines fell under the following categories: (a) adaptability; (b) affordability; and (c) inclusiveness.

Adaptability Considerations

Microsoft [69] indicated that it is necessary to ensure that systems operate consistently and as designed, not just in controlled lab settings but also in real-world scenarios, especially when faced with evolving challenges:

> "*A reliable system functions consistently and as intended, not only in the lab conditions in which it is trained, but also in the open world or when they are under attack from adversaries*".

VMware [86] underscored the necessity of a component-based design of AI-driven systems in response to the contingencies of use:

> "*Where appropriate, AI-powered systems should have control mechanisms to allow human operators to deactivate the AI component without affecting business continuity*".

In addition, NVIDIA [89] highlighted the technical flexibility of their products and provided various programs and tools to allow developers to create and accelerate applications for specific purposes and industries:

> "*Our products are programmable and general purpose in nature*".

Palantir [91] also highlighted this point and presented the benefits of their product's interoperable and extensible architecture:

> "*Foundry's interoperable and extensible architecture has enabled data science teams worldwide to readily collaborate with their business and operational teams, enabling all stakeholders to create data-driven impact*".

Furthermore, Samsung [92] put forward that their pursuit of technological innovation aims to provide equal and easy access for all users:

> "*We seek technological innovation to allow equal and convenient access to our products and services by all consumers. We apply the 4C Accessibility Design Principles when developing our products and services*".

Thus, we underline that TMPSs should allow operating seamlessly with other systems for compatibility and integration, remain adaptable to evolving socio-technical challenges while serving their intended purposes throughout their lifecycle, and ensure accessibility for everyone. Table 7 presents our recommendations for specific objectives and statements within the context of adaptability considerations.

Table 7. Objectives of adaptability considerations.

Adaptability Considerations		
Objectives		**Statements**
OBJ 10	Flexible in nature	Allows individual modification or replacement and can seamlessly operate with other systems to ensure compatibility and ease of integration.
OBJ 11	Future-proof design	Remains adaptable in the face of evolving socio-technical challenges and paradigms and continues to serve intended purposes throughout their lifecycle.
OBJ 12	Universal access	Ensures accessibility for all individuals, irrespective of differences in physical ability, technological, cognitive, or actual usage context.

Affordability Considerations

The investigated technology companies seldom discussed the affordability of technology and provided only a few broad and ambiguous statements on this consideration. For example, Samsung [92] contended:

> "*We seek technological innovation to allow equal and convenient access to our products and services by all consumers*".

And Atlassian [87] claimed:

> "*We work for social and environmental progress in whatever we do, which includes a commitment to respect human rights; to invest in the diversity, equity, and inclusion of our teams and larger ecosystem; and to make Atlassian products and experiences fully accessible and usable for everyone*".

Nevertheless, we contend that thoroughly considering affordability is crucial to broaden the notions of technology accessibility, especially from a user-friendly perspective [93–95]. Therefore, this paper underscores that TMPSs should provide cost-effective solutions to diminish economic disparities in adoption. Technology outcome providers should attempt to decrease costs to facilitate access for wider population segments without financial setbacks and offer genuine value. This ensures that users receive benefits that justify the expenses, thus promoting lasting adoption and utility. Table 8 presents our recommendations for specific objectives and statements within the context of affordability considerations.

Table 8. Objectives of affordability considerations.

Affordability Considerations		
Objectives		**Statements**
OBJ 13	Cost-effective solution	Provides cost-effective solutions or alternatives to reduce economic disparities in technology adoption.
OBJ 14	Financial feasibility	Reduces costs to allow broad population segments to access and benefit from innovation and technological advances without negative financial implications.
OBJ 15	Value for money	Offers genuine value, ensuring that users receive meaningful benefits or solutions that justify the costs, promoting long-term adoption and utility.

Inclusiveness Considerations

Intel [67] signifies the importance of equity, inclusion, and cultural awareness in AI development and deployment:

> "*We believe there is a need for equity, inclusion, and cultural sensitivity in the development and deployment of AI. We strive to ensure that the teams working on these technologies are diverse and inclusive. We believe that the AI technology domain should be developed and informed by diverse populations, perspectives, voices, and experiences*".

IBM [66] indicates that unintended outcomes could manifest in both AI system algorithms and the data used for their training and testing. For instance, algorithmic bias might

stem from the influences of cultural, social, or institutional norms. While it is challenging to eradicate all these consequences entirely, IBM believes it is imperative for a responsible team to embrace diverse perspectives. By ensuring a comprehensive collection of diverse and representative data and experiences, these influences on AI systems can be minimised:

> "*Diverse teams help to represent a wider variation of experiences*".

> "*Embrace team members of different ages, ethnicities, genders, educational disciplines, and cultural perspectives*".

> "*Although bias can never be fully eliminated, it is the role of a responsible team to minimize algorithmic bias through ongoing research and responsible data collection representative of a diverse population*".

Salesforce [96] believes that AI ought to enhance the human condition and embody the values of everyone affected, not just its developers:

> "*AI should improve the human condition and represent the values of all those impacted, not just the creators. We will advance diversity, promote equality, and foster equity through AI*".

VMware [86] states that integrating social diversity and inclusiveness into the innovation process can lead to better and more responsible results, particularly in AI practices:

> "*Diversity and inclusiveness in society result in teams that generate better outcomes—including in the practice of AI*".

Automatic Data Processing [97] espouses similar views and believes that diverse teams are crucial for designing and developing AI applications. This diversity guarantees the inclusion of a broad spectrum of perspectives and experiences. Given that AI applications influence humans, it is vital that human experiences shape their impacts:

> "*We are committed to having diverse teams design and develop our ML models, to ensure a wide variety of perspectives and experience are considered. After all, ML models impact humans, and human experience should inform that impact*".

Thus, this paper emphasises that TMPSs should respect shared values and be attuned to diverse cultural nuances, ensuring the inclusion and representation of marginalised or underrepresented groups in innovation practices. Additionally, we consider that technology localisation is essential to ensure that TMPSs respect and align with local customs, languages, and preferences, maintaining relevance in various geo-cultural contexts. Table 9 presents our recommendations for specific objectives and statements within the context of inclusiveness considerations.

Table 9. Objectives of inclusiveness considerations.

Inclusiveness Considerations		
Objectives		**Statements**
OBJ 16	Cultural and contextual sensitivity	Respects shared values while remaining sensitive and attuned to the nuances of diverse cultural norms and contexts.
OBJ 17	Diverse representation	Ensures marginalised or underrepresented groups are included and have representation in innovation and technology practices.
OBJ 18	Localisation-friendly	Localises to match local customs, languages, and preferences, ensuring relevance and acceptance in different geo-cultural contexts.

4.2.3. Alignment Goals

The insights gleaned from the 'alignment goals' category highlight as a key consideration that technology companies aim to ensure that their policies include the objective that technologies, products, or services are aligned with societal desirability and preferences

as well as common human values to deliver positive outcomes. The most noticeable considerations linked to alignment goals in RIT guidelines fell under the following categories: (a) deliberateness; (b) meaningfulness; and (c) sustainability.

Deliberateness Considerations

Amazon [98] indicated that AI applications span a vast range of use cases, each with its unique goals, user demographics, and potential outcomes. While certain applications might pose minimal risks, others could have profound implications, especially when they affect human rights or safety. It is crucial for developers to weigh both the benefits and potential hazards specific to their AI application:

> "*There are a wide variety of use cases that may incorporate ML, with different goals, characteristics, user bases, and potential impacts. Developers should consider the benefits and potential risks of their specific use case. Given the broad nature and applicability of ML, many applications may pose limited or no risk (e.g., movie recommendation systems), while others could involve significant risk, especially if used in a way that impacts human rights or safety*".

Further, Google [74] signified that their design approach for AI applications is rooted in caution and aligned with the best practices in AI safety research:

> "*Designed to be appropriately cautious and in accordance with best practices in AI safety research, including testing in constrained environments and monitoring as appropriate*".

In addition, Adobe [84] declared they would commit to designing and sustaining their AI applications through a thorough evaluation process, always being mindful of the potential impacts and consequences that arise from their deployment:

> "*We will approach designing and maintaining our AI technology with thoughtful evaluation and careful consideration of the impact and consequences of its deployment*".

Vmware [86] espoused similar views and further indicated the importance of ensuring that AI systems operate as intended. They advocated that meticulous planning and deliberation are paramount in developing AI systems to ensure they function accurately and consistently in line with their designers' expectations:

> "*It is critical to take steps to ensure that AI systems function according to their design purpose*". "*Careful forethought is needed to develop AI systems that accurately and consistently operate in accordance with their designers' expectations*".

Workday [71] promised that they are both thoughtful and deliberate in their AI development, committing to producing AI solutions strictly in alignment with the core human values they recognise and respect:

> "*We're thoughtful and deliberate in our approach at Workday, and we only develop AI solutions that align with our values*".

Thus, this paper underlines that TMPSs should be designed with a clearly defined intended purpose consistent with overall goals and values. Developers should anticipate and strategise against potential adverse outcomes while deeply understanding users' needs and preferences to ensure relevant and effective solutions. Table 10 presents our recommendations for specific objectives and statements within the context of deliberateness considerations.

Table 10. Objectives of deliberateness considerations.

Deliberateness Considerations		
Objectives		**Statements**
OBJ 19	Define the purpose	Before taking any initiative or action, clarifies and articulates the intended purpose to ensure alignment with overall goals and values.
OBJ 20	Proactive risk assessment	Anticipates potential negative outcomes, challenges, or pitfalls, and designs strategies to mitigate or avoid them.
OBJ 21	User relevance	Gains a deep understanding of the users' needs, preferences, and challenges to ensure the solutions provided are directly relevant to and satisfy the end-user's needs.

Meaningfulness Considerations

Sony [85] are aware of the profound effects that AI-driven products and services can have on society. They are committed to actively contributing to AI development with the goal of fostering a better society:

> "*Sony will be cognizant of the effects and impact of products and services that utilize AI on society and will proactively work to contribute to developing AI to create a better society and foster human talent capable of shaping our collective bright future through R&D and/or utilization of AI*".

Baidu [99] believes that the true essence of AI lies in its potential to enable human growth and learning, rather than to outdo or replace humanity. Their ultimate vision for AI is to usher in greater freedom and myriad opportunities for humankind:

> "*The value of AI is to empower mankind to learn and grow instead of surpassing and replacing mankind; the ultimate ideal of AI is to bring more freedom and possibilities to humankind*".

Salesforce [96] espouses similar views and indicates that AI technology is truly useful when combined with human capabilities:

> "*We believe AI is best utilized when paired with human ability, augmenting people, and enabling them to make better decisions. We aspire to create technology that empowers everyone to be more productive and drive greater impact within their organizations*".

Workday [71] declares that their AI design primarily aims to assist customers and their employees in unlocking potential and concentrating on impactful tasks. Their offerings are committed to enhancing human decision-making and empowering users to choose whether to follow the suggestions given by their AI-driven solutions:

> "*We design AI to help our customers and their employees unlock opportunities and focus on meaningful work. Our solutions support human decision-making, improve experiences, and put users in control to decide whether to accept the recommendations provided by our AI-based solutions*".

Sony [85] believes that promoting the harmonious integration of AI into society can not only bolster individual empowerment but also contribute to sustainable societal progress:

> "*Through advancing its AI-related R&D and promoting the utilization of AI in a manner harmonized with society, Sony aims to support the exploration of the potential for each individual to empower their lives, and to contribute to enrichment of our culture and push our civilization forward by providing novel and creative types of Kando. Sony will engage in sustainable social development and endeavor to utilize the power of AI for contributing to global problem-solving and for the development of a peaceful and sustainable society*".

In addition, Airbnb [100] offers another perspective regarding how technology supports local communities:

> "*We help create new sources of income for Hosts sharing their existing spaces and skills, making it possible to empower them financially while fostering connection with people from around the world and supporting local communities in the process*".

Atlassian [87] indicates that by responsibly and purposefully employing these technologies, they can promote even more positive impact within our communities:

> "*We know that behind every great human achievement, there is a team. We also believe that new technologies can help empower those teams to achieve even more. If we use these technologies (like AI) responsibly and intentionally, then we can supercharge this vision and contribute to better outcomes across our communities*".

Thus, this paper advocates that TMPSs should aim to unlock humanity's potential to tackle complex challenges and champion human welfare across generations, ensuring growth, prosperity, and positive societal impact. Moreover, we contend that securing continuous community recognition is essential for the harmonious integration of TMPSs into society. Table 11 presents our recommendations for specific objectives and statements within the context of meaningfulness considerations.

Table 11. Objectives of meaningfulness considerations.

Meaningfulness Considerations		
Objectives		**Statements**
OBJ 22	Realise human potential	Unlocks humanity's potential, empowering individuals to address complex challenges effectively with increased capability through complementary collaboration with technology.
OBJ 23	Social license to operate	Strives for continuous community recognition, emphasising legitimacy, trust, and ethical alignment beyond mere regulatory compliance.
OBJ 24	Socially beneficial	Promotes human welfare for both current and future generations, fostering growth, prosperity, and positive societal outcomes.

Sustainability Considerations

Based on these results, we found that the theme of sustainability is not elaborated upon in the guidance documents focusing on RIT. However, it is thoroughly discussed in corporate annual reports such as the Environmental, Social, and Governance (ESG) Report, Corporate Responsibility Report, and Sustainability Report. This may be because technology companies believe that achieving sustainability goals should be an overall commitment or vision for the entire company, rather than being limited to specific technologies, products, or services. Nevertheless, some companies do include brief discussions on sustainability considerations related to specific technologies and products in their guidance documents.

For example, NVIDIA [89] promoted a central objective throughout their research, development, and design stages, which is to enhance performance while optimising energy efficiency. Their goal for each successive generation of products is to outperform and be more energy-efficient than the last. Additionally, they claimed that their technology plays a pivotal role in pioneering advancements in climate modelling, carbon emission reductions, and the development of strategies to adapt to and mitigate the effects of global changes:

> "*Improving performance and energy efficiency is a principal goal in each step of our research, development, and design processes. We aim to make every new generation of GPUs faster and more energy efficient than its predecessor. And our technology is driving some of the most important advances for modelling our climate, reducing carbon emissions, and designing mitigation and adaptation strategies in a changing world*".

Furthermore, Vmware [86] signified that the potential environmental impact of AI applications needs to be evaluated. The creation and use of AI technologies should not only be consistent with, but also reinforce, the company's ESG objectives:

> "*AI systems should be assessed regarding their impact on the environment. The development and consumption of AI technologies should align with and support the company's ESG goals*".

Based on additional findings from the corporations' annual reporting documents, this paper emphasises that TMPSs should target supporting global climate change adaptation and

mitigation, adopt an eco-friendly design approach, and prioritise the longevity of technological outcomes in the design and production process. Table 12 presents our recommendations for specific objectives and statements within the context of sustainability considerations.

Table 12. Objectives of sustainability considerations.

Sustainability Considerations		
Objectives		**Statements**
OBJ 25	Commitments to climate change	Targets a reduction in greenhouse gas emissions and prevention of waste generation, supporting global efforts to adapt to and mitigate climate change.
OBJ 26	Design for longevity	Ensures resources invested in creating products or solutions provide value over the long term and contribute to more sustainable and resilient societies.
OBJ 27	Eco-friendly design	Incorporates environmental considerations starting from the design phase to ensure products or solutions are eco-friendly throughout their lifecycle.

4.2.4. Trustworthiness Goals

The insights gleaned from the 'trustworthiness goals' category highlighted as key considerations that technology companies aim to ensure that their policies include the objective that their products or services can establish trust among stakeholders, end-users, and the wider public. The most noticeable considerations linked to trustworthiness goals in RIT guidelines fell under the following categories: (a) explainability; (b) security; and (c) transparency.

Explainability Considerations

Oracle [68] stated the complexity of AI can hinder explainability, posing challenges in sectors where accountability is crucial:

> "*AI systems can be difficult to understand, which can make it challenging to explain their decisions and assess their performance, for example, a medical-diagnosis AI system that can't explain its decision-making process, or a criminal-risk-assessment AI system that has a high rate of false positives for certain demographic groups*".

Microsoft [69] signified that improving the explainability of AI helps to meet the challenges and also enhance user trust and product usability:

> "*Intelligibility can uncover potential sources of unfairness, help users decide how much trust to place in a system, and generally lead to more usable products*".

NXP Semiconductors [70] espoused similar views and provided clear statements to describe the goal of explainability:

> "*We encourage explainability and transparency of AI-decision-making processes in order to build and maintain trust in AI systems*". "*The goal of interpretability is to describe the internals of the system in a way that is understandable to humans. The system should be capable of producing descriptions that are simple enough for a person to understand. It should also use a vocabulary that is meaningful for the user and will enable the user to understand how a decision is made*".

Moreover, Sony [85] stated that they would capture AI decision reasoning in product design and provide clear explanations about potential impacts to customers using AI-integrated products and services:

> "*During the planning and design stages for its products and services that utilize AI, Sony will strive to introduce methods of capturing the reasoning behind the decisions made by AI utilized in said products and services. Additionally, it will endeavor to provide intelligible explanations and information to customers about the possible impact of using these products and services*".

Thus, this paper highlights that TMPSs should provide valid reasons for any decisions while ensuring the decisions are aligned with established objectives. Systems

should offer consistent and clear interpretations across scenarios and present results in a manner understandable to users irrespective of their technical expertise. Table 13 presents our recommendations for specific objectives and statements within the context of explainability considerations.

Table 13. Objectives of explainability considerations.

Explainability Considerations		
Objectives		**Statements**
OBJ 28	Comprehensive explanation	Consistently provides clear and understandable interpretations across a range of inputs and scenarios, rather than being limited to specific instances or datasets.
OBJ 29	Interrogable justification	Provides valid and clear reasons for decisions, operations, or predictions, aligned with pre-defined objectives and standards.
OBJ 30	Intuitive interpretation	Presents operations and outcomes in a manner that is immediately comprehensible to users, irrespective of their technical expertise.

Security Considerations

Samsung [92] indicated that awareness of advanced cyberattacks and their potential damages is central to security considerations:

> "*Awareness about cybersecurity and the potential for damages caused by increasingly sophisticated cyberattacks remains at the forefront of our security considerations*".

Dell [101] signified AI systems and their marketable products and services must ensure their safety and reliability:

> "*AI systems should be safe and reliable, guarding the wellbeing of users and yielding results consistent with our values*".

Similarly, Oracle [68] explained that the security and safety of AI applications is crucial for end-users and the public:

> "*AI systems can be used in applications such as self-driving cars, military drones, and medical treatments. Ensuring that these systems are safe for their intended users and the public is crucial*".

NXP Semiconductors [70] embedded top-tier security and data protection into every aspect, from design and functionality to operations and business models:

> "*We must adopt the highest appropriate level of security and data protection to all hardware and software, ensuring that it is pre-configured into the design, functionalities, processes, technologies, operations, architectures and business models*".

Furthermore, Equinix [102] pointed out effective data governance is necessary to ensure the security of AI practices and applications:

> "*In order to ensure the integrity of their AI outcomes, businesses must verify that none of these inputs have been corrupted and put rigorous checks in place to ensure data security and integrity". "In addition to protecting data integrity, data governance is also essential to providing the context that goes along with your AI outcomes*".

Thus, this paper advocates that TMPSs should incorporate systematic measures to protect digital assets and hardware against threats. Additionally, an ethical and compliant data governance approach should be adopted to maintain stakeholder trust. Table 14 presents our recommendations for specific objectives and statements within the context of security considerations.

Table 14. Objectives of security considerations.

Security Considerations		
Objectives		**Statements**
OBJ 31	Data security governance	Adopts ethical, safe, and regulatory-compliant data management mechanisms, ensuring security of organisational data and stakeholders' privacy, and upholding trust amidst innovation practices.
OBJ 32	Digitally secure	Establishes systematic measures to protect digital assets, data, and user privacy, ensuring user trust and building a resilient digital ecosystem.
OBJ 33	Physically secure	Implements tangible measures to protect hardware and data storage, ensuring operational continuity and guarding against physical threats to innovation and digital ecosystems.

Transparency Considerations

NVIDIA [89] acknowledged technology's profound effects on cities and societies. In their guidance document, NVIDIA explained that the company aims to promote positive change and ensure trust and transparency in AI development:

> "*Recognizing that technology can have a profound impact on people and the world, we've set priorities that are rooted in fostering positive change and enabling trust and transparency in AI development*".

Cisco [73] prioritised transparency in their AI development process as well. They emphasised the importance of informing customers when AI influences their decisions and of responding to feedback, with the goal of nurturing and enhancing trust in their AI offerings among all stakeholders:

> "*As transparency is one of our Trust Principles and core to this framework, we inform customers when AI is being used to make decisions that affect them in material and consequential ways. Customers and users can then inform us of their concerns or let us know when they disagree with decisions. By keeping communications channels open, we intend to build, maintain, and grow the trust that our customers, users, employees, and other stakeholders place in our AI offerings*".

Moreover, NXP Semiconductors [70] indicated that users' awareness of their interactions with intelligent systems is critical for transparency reasons:

> "*Users need to be aware that they are interacting with an AI system, and they need the ability to retrace that AI system's decisions*".

Dell [101] emphasised that users should have disclosure and control over AI interactions and data use:

> "*Users should be provided appropriate disclosures and control over their interactions with AI and its use of their data*".

Additionally, Palantir [91] stated that transparency should permeate entire AI solutions, from model development to post-deployment, enabling users to utilise AI responsibly and efficiently for organisational challenges:

> "*These objectives also transparently communicate state about a particular AI/ML solution—from model development to testing, to deployment and further post-deployment actions like monitoring and upgrades. This enables users to be more intentional, responsible, and effective in how they use AI to address their organization's operational challenges*".

Thus, this paper underscores that TMPSs should disclose substantial stakeholder-affecting issues transparently and consistently inform users about their interactions with intelligent systems to foster autonomy and prevent misuse. Additionally, there is a need to ensure that the architecture, training data, algorithms, and operational works are open and available for review to ensure transparency. Table 15 presents our recommendations for specific objectives and statements within the context of transparency considerations.

Table 15. Objectives of transparency considerations.

Transparency Considerations		
Objectives		**Statements**
OBJ 34	Appropriate disclosure	Transparently discloses issues and matters that substantially affect stakeholders, equipping those engaging with innovation and new technologies with comprehensive information.
OBJ 35	Aware of interaction	Ensures users are consistently informed about their interactions with intelligent systems to promote user autonomy and prevent misuse or unintended consequences.
OBJ 36	Openness of structure	Existence of architecture, training data, algorithms, and operational works that are open, clear, and available for review.

4.2.5. Well-Governance Goals

The insights gleaned from the 'well-governance goals' category highlighted the key considerations that technology companies emphasise to ensure that their technologies, products, or services are managed well to deliver the desired outcomes for cities and societies. The most noticeable considerations linked to well-governance goals in RIT guidelines fell under the following categories: (a) accountability; (b) participation; and (c) regulatory.

Accountability Considerations

Palantir [91] indicated that for AI solutions to be used both responsibly and effectively, they must possess the qualities of traceability, auditability, and governability:

> "*AI solutions must be traceable, auditable, and governable in order to be used effectively and responsibly*".

Cisco [73] believes that accountability throughout the AI practice lifecycle is paramount for responsible development and operation. Given that AI tools can serve multiple purposes, including unforeseen or unintended applications, providers must take on the responsibility to ensure AI solutions function as intended and to prevent misuse:

> "*Accountability for AI solutions and the teams that develop them is essential to responsible development and operations throughout the AI lifecycle. AI tools often have more than one application, including unintended use cases and uses that might not have been foreseeable at the time of development. Companies that develop, deploy, and use AI solutions must take responsibility for their work in this area by implementing appropriate governance and controls to ensure that their AI solutions operate as intended and to help prevent inappropriate use*".

Vmware [86] pointed out that individuals within the development organisation must be held accountable for every stage of an AI-powered system, from its conception to deployment. This includes taking responsibility for the system's outcomes, results, and any subsequent consequences of its utilisation:

> "*Individuals in your organization should be accountable for the ideation, design, implementation, and deployment of each AI-powered system they create and/or use—including the outcomes, results, and consequences of its use*".

Automatic Data Processing [97] expressed that they have established audit procedures and risk assessments as foundational management methods for their AI applications. They remain committed to constantly overseeing and refining their models and systems, ensuring that variations in data or model conditions do not adversely influence the anticipated outcomes:

> "*We have implemented audit and risk assessments to test our ML models as the baseline of our oversight methodologies. We continue to actively monitor and improve our models and systems to ensure that changes in the underlying data or model conditions do not*

inappropriately affect the desired results. And we apply our existing compliance, business ethics, and risk management governance structures to our ML development activities".

Amazon [98] proposed the need for mechanisms that monitor and review processes during the AI system's development and operation. By setting up a traceable record, both internal and external groups can effectively assess the AI system's development and operation:

"*Consider the need for implementing mechanisms to track and review steps taken during development and operation of the ML system, e.g., to trace root causes for problems or meet governance requirements. Evaluate the need to document relevant design decisions and inputs to assist in such reviews. Establishing a traceable record can help internal or external teams evaluate the development and functioning of the ML system*".

Furthermore, Adobe [84] signified their commitment to taking responsibility for the results of their AI-enhanced tools as well as dedicating processes and resources in place to address any concerns related to their AI and are prepared to make necessary adjustments if needed:

"*We take ownership over the outcomes of our AI-assisted tools. We will have processes and resources dedicated to receiving and responding to concerns about our AI and taking corrective action as appropriate*".

Thus, this paper advocates that TMPS should contain accountability procedures to identify responsible parties and rectify harm or errors clearly. Additionally, the comprehensive records of decisions and processes should be maintained to allow for open audits. Table 16 presents our recommendations for specific objectives and statements within the context of accountability considerations.

Table 16. Objectives of accountability considerations.

Accountability Considerations		
	Objectives	**Statements**
OBJ 37	Redress and remediation	Establishes procedures to rectify any harm or mistakes, compensating affected parties when necessary.
OBJ 38	Responsibility attribution	Clearly identifies parties responsible for decisions, outcomes, or errors arising from innovation and technology practices.
OBJ 39	Traceable records	Maintains detailed records of decisions, justifications, processes, and outcomes and ensures the records are accessible to relevant stakeholders.

Participation Considerations

Sony [85] highlighted the importance of participatory discussion with various stakeholders to address the challenges presented by AI applications. They indicated that by fostering dialogues with industry peers, organisations, and academic communities, the interests and concerns of stakeholders would get better attention and consideration in AI development:

"*. . . Sony will seriously consider the interests and concerns of various stakeholders including its customers and creators, and proactively advance a dialogue with related industries, organizations, academic communities and more. . . Sony will construct the appropriate channels for ensuring that the content and results of these discussions are provided to officers and employees, including researchers and developers, who are involved in the corresponding businesses, as well as for ensuring further engagement with its various stakeholders*".

Schneider Electric [88] promoted that collaborating through co-innovation and forming strategic partnerships are essential to fully leverage the capabilities of AI and expedite its developmental journey:

> "*Co-innovation and partnerships are key to harness the power of AI and accelerate the AI journey*".

NXP Semiconductors [70] expressed that, through cross-disciplinary scientific methods, they advocate for thought leadership in AI, aiming to further enhance AI technologies and their associated practices:

> "*Drawing on rigorous and multidisciplinary scientific approaches, we promote thought leadership in this area in close cooperation with a wide range of stakeholders. We will continue to share what we've learned to improve AI technologies and practices. Thus, in order to promote cross-industrial approaches to AI risk mitigation, we foster multi-stakeholder networks to share new insights, best practices and information about incidents*".

Meta Platforms [103] denoted the necessity for a collective effort involving not just themselves but also the broader tech industry, AI researchers, policymakers, and advocacy groups to establish clear standards for AI impact assessment. This collaborative approach helps to pinpoint and mitigate potential negative effects of AI while continuing to develop AI-driven products for the greater good:

> "*We—not just Facebook but also the tech industry, the AI research community, policymakers, advocacy groups, and others—need to collaborate on figuring out how to make AI impact assessment work at scale, based on clear and reasonable standards, so that we can identify and address potential negative AI-related impacts while still creating new AI-powered products that will benefit us all*".

In addition, Atlassian [87] claimed they are committed to establishing feedback procedures that allow them to gather insights from their stakeholders and draw guidance both from within and outside the company:

> "*We are committed to putting in place processes that help us to obtain feedback from our stakeholders and take guidance from experts, internally and externally. We encourage our customers to tell us if something has gone wrong. In those cases, we will investigate and work to fix it*".

Dell [101] has views that support this point and states that AI applications' development and deployment necessitate periodic evaluations by diverse professionals, spanning legal, ethics, technical, and business fields, to guarantee continuous compliance and transparency:

> "*The development and implementation of AI applications should be periodically reviewed by both internal and external legal, ethics, technical and business professionals to ensure ongoing compliance and transparency*".

Thus, this paper emphasises that TMPS should adopt the co-design approach for direct stakeholder contributions and provide ongoing feedback procedures to refine innovations. A collaborative governance method can be applied to ensure technological outcomes align with the broader public interest by inviting diverse stakeholder participation. Table 17 presents our recommendations for specific objectives and statements within the context of participation considerations.

Regulatory Considerations

Schneider Electric [88] highlighted that in AI and data science development, the first principle is to ensure ethics and compliance:

> "*The number one rule we apply when developing AI and data science is ethics and compliance in line with our Trust Charter*".

Sony [85] indicated they are committed to ensuring that their AI-integrated products and services adhere to both legal standards and their own internal guidelines. This commitment is based on their vision of respecting the intentions and trust of their customers:

> "*Sony, in compliance with laws and regulations as well as applicable internal rules and policies, seeks to enhance the security and protection of customers' personal data acquired via products and services utilizing AI, and build an environment where said personal data is processed in ways that respect the intention and trust of customers*".

Table 17. Objectives of participation considerations.

Participation Considerations		
Objectives		**Statements**
OBJ 40	Collaborative governance	Embraces a collaborative governance model which invites diverse stakeholders to jointly shape and monitor innovation practices, ensuring that technological outcomes resonate with and serve the wider public interest.
OBJ 41	Cooperative design	Facilitates co-design sessions to allow potential users and other stakeholders to directly contribute to the innovation's design or refinement.
OBJ 42	Feedback loops	Establishes mechanisms that allow for continuous feedback from users and stakeholders to adapt the innovation accordingly.

Amazon [98] stated that they actively consult with legal experts when developing AI to ensure AI-driven applications meet all regulatory requirements. They also emphasise the importance of being aware of varying legal stipulations across different regions and of the emerging AI regulations globally, ensuring continuous legal assessment throughout the deployment and operational phases:

> "*Engage with legal advisors to assess requirements for and implications of building your ML system. This may include vetting legal rights to use data and models, and determining applicability of laws around privacy, biometrics, anti-discrimination, and other use-case specific regulations. Be mindful of differing legal requirements across states, provinces, and countries, as well as new AI/ML regulation being considered and proposed around the world. Re-visit legal requirements and considerations through future deployment and operations phases*".

Workday [71] advocated for practical, risk-based regulatory strategies that foster trust in AI technology while promoting innovation:

> "*We engage U.S. federal, state, and local governments, the European Union, and other governments around the world to advocate for workable, risk-based regulatory approaches that build trust in AI technology and enable innovation. As our development process continues to evolve to account for new best practices and emerging regulatory frameworks, we remain committed to supporting the delivery of trustworthy AI solutions that provide value to our customers, the workforce, and society*".

Furthermore, Dell [101] denoted that the implementation and utilisation of AI should not only adhere to global laws in both essence and letter but also remain consistent with corporate conduct codes and emerging ethical standards. They underscored the importance of periodic reviews of AI applications by a diverse group of experts, spanning legal, ethical, technical, and business sectors, to guarantee sustained compliance and transparency:

> "*The implementation and use of AI should comply with the letter and spirit of globally applicable laws, be consistent with corporate codes of conduct and align with an evolving consensus on ethical practices. The development and implementation of AI applications should be periodically reviewed by both internal and external legal, ethics, technical and business professionals to ensure ongoing compliance and transparency*".

Thus, this paper emphasises that TMPSs should not only observe industry-specific best practices and codes but also adhere to global laws in both intent and implementation. Furthermore, they need to undergo independent reviews regularly to ensure proper functioning and proactive prevention of misuse, all while remaining adaptable to changing

regulatory environments. Table 18 presents our recommendations for specific objectives and statements within the context of regulatory considerations.

Table 18. Objectives of regulatory considerations.

Regulatory Considerations		
Objectives		**Statements**
OBJ 43	Consistent with best practice guidelines	Observes industry-specific best practices, standards, and codes of conduct that might be set by professional bodies or associations.
OBJ 44	Legal compliance	Adheres to both the letter and spirit of global laws and regulations, while ensuring that innovation and technological outcomes remain adaptable to evolving regulatory landscapes.
OBJ 45	Periodic and independent review	Regularly conducts independent reviews of innovation and technology systems and adjusts as needed to ensure they function as intended and to pre-emptively deter misuse.

The completed responsible innovation and technology assessment framework is provided in Table A1.

5. Discussion

Our research findings indicate that the selected companies largely focus their RIT considerations on AI. This focus may be attributed to several interrelated factors. Firstly, AI is at the forefront of technological advancements, often deemed a pivotal driver of the Fourth Industrial Revolution (Industry 4.0) and the emerging Fifth Industrial Revolution (Industry 5.0) [104–106]. The transformative potential of AI across various sectors necessitates a concentrated effort to ensure its development aligns with ethical, legal, and social norms—a common tenet of RIT. Secondly, AI systems raise unique challenges, such as opacity (the 'black box' problem), algorithmic bias, and questions of accountability, which may demand appropriate RIT guidance to manage [64,107]. Finally, as public concerns related to privacy, autonomy, and decision-making bias of AI-driven products and services are rising, these leading technology companies may strategically prioritise AI in their RIT agendas to mitigate risks, align with regulatory trends, and bolster public confidence in their commitment to responsible innovation.

Consistent with the above, our findings discovered that these companies' key areas of emphasis include the trustworthiness and acceptability of technology and its marketable products and services (TMPSs), particularly concerning privacy-related challenges. Notably, discourse surrounding the affordability of technological outcomes and their subsequent adoption is limited. Additionally, while in-depth discussions on sustainability within the RIT context are lacking, this consideration is notably presented in their annual corporate reporting documents, such as the ESG Report, Corporate Responsibility Report, and Sustainability Report.

After synthesising the perspectives of leading technology companies on the RIT concept, this paper has formulated a multifaceted evaluation approach to ensure that TMPSs align with the ultimate goals of the concept. The framework encompasses five interconnected pillars guiding organisations toward responsible innovation processes and product design strategy: *acceptability*, *accessibility*, *alignment*, *trustworthiness*, and *well-governance*.

The *acceptability goal* stresses the importance of ensuring TMPSs are aligned with human and social values while ensuring they are ethical and equitable and avoid harm to individuals, society, and the environment. This is critical as technologies like AI become increasingly integrated into every aspect of life; the way they are designed and deployed may have profound effects on individuals, society, and the environment, e.g., the cultural and creative industry [108], healthcare field [109], and public sector [110]. For example, an AI recruitment tool must be free from biases that could lead to discrimination, adhering to fairness as a fundamental principle, and the algorithms should be audited for bias. Tubadji et al. [108] indicated existing AI technology still grapples with a fundamental

challenge: the capacity to connect with human emotions and, notably, the capability to intuitively grasp moral attitudes and values that define the essence of humanity. Acceptability should be the threshold for responsible AI and appears to be a key element for overcoming this challenge [110]. When AI provides societally unacceptable results (for example violating fundamental human rights or common values), this form of AI application should not be accepted because there are no identifiable ethically acceptable trade-offs [111].

The *accessibility goal* ensures that TMPSs are within reach for all sections of society, breaking down barriers related to affordability, cultural context, and usability. The purpose is to ensure technological achievements are not just for the minority but serve a broader demographic. In essence, the accessibility goal calls for a more inclusive approach to the design and deployment of TMPSs, whether in technical, financial, or cultural terms. This goal aligns with the broader goals of social justice and equity to foster a more inclusive digital future [112–114]. A familiar example is providing multilingual and multiform software interfaces that cater to wider user groups, thus embodying the inclusivity principle.

The *alignment goal* demands that TMPSs align with the broader objectives of societal and environmental well-being [26,39]. It emphasises the need for deliberate, meaningful, and sustainable innovation that recognises the interconnectedness of technology, society, and the natural world, and strives to create a positive impact on all these fronts [115–117]. This goal focuses on ensuring that industries and their outputs harmonise with broader societal and environmental objectives. Organisations should change their focus from the classical 'market and technology-driven' innovation perspective to pursuing broader social and environmental values to fulfil social responsibility [117–119]. For instance, a company could commit to reducing its carbon footprint by designing energy-efficient products, thereby aligning its mission with sustainability goals [120].

As technology becomes more complex and pervasive in our cities and societies, ensuring the trustworthiness of TMPSs is paramount [121–123]. Existing information system studies highlighted that the relationship between humans and technology is influenced by trust. This is because trust plays a crucial role as a precursor to engaging in risk-taking or adoption behaviours [124–126]. The *trustworthiness goal* emphasises the need for robust measures to protect data and provide transparency so that users can understand and trust the products they use [127,128]. By focusing on these considerations, companies can foster a strong relationship of trust with their users, which is essential in a digital age characterised by frequent data breaches and concerns over privacy and misuse of technology [129,130]. A company could, for example, adopt transparent data practices and explain to users how their data are used and protected, thus enhancing trustworthiness.

Finally, contemporary organisations are seen as the main setting for responsible innovation. Due to the inherent uncertainty in predicting innovation outcomes, which often leads to previously unencountered results, it is essential to govern responsibly, especially starting from the early stages of research and development. This is crucial to achieving responsible innovation goals within a business context [115,131]. The *well-governance goal* is to ensure that TMPSs are developed and managed responsibly. It covers accountability, regulatory compliance, and participation, ensuring that companies are accountable for their actions, decisions, and products, especially those that may affect customers, society, and the environment [25,107]. A practical example could be setting up a governance board that includes customer representatives, industry experts, and other relevant parties. Their participation ensures that a wide range of views and interests are considered, thus operationalising the well-governance goal [115,131].

While the technology companies highlight a predominant focus on RIT considerations within the realm of AI, it is crucial to recognise the broader technological landscape, especially in the context of Industry 4.0 and the emerging Industry 5.0 paradigms. Technologies such as the Internet of Things (IoT) and the Industrial Internet of Things (IioT) play pivotal roles in shaping a hyper-connected world. In addition, other closely related technologies, like blockchain, augmented reality, and robotics, underpin the digital transformation of industries and societies [132–136]. Each of these technologies may present ethical, societal,

environmental, or regulatory challenges that warrant rigorous RIT considerations. Industries, especially global technology giants, need to broaden their RIT focus to encompass this wider range of technologies, ensuring that we do so responsibly as we move towards an even more interconnected future.

Given the distinct industry or business backgrounds of various companies, their priorities concerning the RIT concept will naturally differ slightly. For instance, companies centred around AI-driven technologies might place a heightened emphasis on ethical considerations, while semiconductor manufacturers could prioritise environmental sustainability. Hence, we suggest that companies should integrate the RIT concept into their corporate missions and values. Enduringly successful companies frequently ascribe their successes to deeply held core values and beliefs that invariably inform their decision-making processes [137]. By incorporating RIT concept, technology companies can harmonise their initiatives with their foundational visions, e.g., "*we do this to respect human rights, encourage innovation, and reflect Cisco's purpose to power an inclusive future for all*" [73], "*we live Atlassian's mission and values in everything we do. . . seek to uphold those values when it comes to understanding what it means to act responsibly in building, deploying and using new technologies*" [87]. Such an alignment not only facilitates coherent and consistent decision-making but also aids in attracting and retaining individuals who resonate with these intrinsic values.

Additionally, this study reveals that leading technology companies place a heightened emphasis on the trustworthiness and acceptability of their technological solutions and results. By striving to shape their products and services to be more 'responsible', these companies aim to garner greater consumer trust and societal approval. We contend that integrating the RIT concept into corporate missions and values not only transcends the consideration of 'doing the right thing', but is also pivotal for following compelling reasons, especially for the private sector:

Assurance of user protection and building trust: Ensuring user protection has become paramount in the contemporary environment, especially given the heightened concerns surrounding data privacy and the potential misuse of AI and related technologies. By adopting RIT practices, companies can proactively address these concerns, thereby reducing risks and bolstering user trust. Companies emphasising security and trust in their technological pursuits may distinguish themselves, thus fostering deeper and more enduring customer relationships, e.g., "*Xiaomi firmly believes that respecting and protecting the security of user's information and user privacy is the only approach to build long-term trust in Xiaomi products and services*" [72], "*our heritage is built on providing trustworthy and innovative solutions to our customers*" [84], "*we will continue to promote responsible AI in order to maintain the trust of products and services by stakeholders*" [85];

Commitment to social responsibility: As companies broaden their influence, the magnitude of their societal impact inevitably intensifies. Beyond profitability, there is a growing recognition of the role companies play in societal well-being. Adopting a vision centred on providing responsible technology and products, in line with a commitment to social responsibility, ensures that this impact is positive for both cities and broader societies, e.g., "*ensuring that our technology and the use of our technology benefits society*" [84], "*to develop technology that supports ethical growth and social responsibility*" [92], "*ensure that AI has a positive impact on society and helps to create a better future for all*" [68]. Furthermore, discerning contemporary consumers frequently favour businesses that prioritise societal welfare over mere profit accrual [116,138];

Compliance with ethical norms and regulations: As governments and international bodies become more stringent about data privacy, ethical technology deployment, and environmental considerations. Proactively aligning with the RIT concept can help companies stay ahead of regulatory curves, ensuring that they are not just reacting to laws but actively shaping and adhering to best practices, e.g., "*understanding the important need for public trust, we work closely with policymakers across the country and around the world as they assess whether existing consumer protections remain fit-for-purpose in an AI era*" [98], "*take appropriate action*

to mitigate that abuse. . .unless we have high confidence that Intel's products are not being used to violate human rights" [67], "*evaluate and mitigate potential legal, reputational, and ethical risks associated with AI use. . . be proactive rather than reactive in addressing AI ethics concerns*" [85];

Obtaining a competitive advantage: The technology industry is fiercely competitive. Companies that embed the RIT concept into their products and services can leverage it as a 'unique' selling point, attracting ethically conscious consumers and partners. It also positions these companies as forward-thinking leaders in the industry, e.g., "*not just because we believe it gives us a competitive advantage, but because it is the right thing to do*" [97], "*to gain a key competitive advantage. . . organization that is committed to ethical AI. . . likely to see better returns from products and services that rely on AI*" [86], "*we are also leading technology industry initiatives to further advance responsible practices in minerals sourcing, mobility, and AI*" [67]. As consumers become more ethically and environmentally conscious, companies that prioritise RIT may differentiate themselves on the market, offering products and services that cater to this growing demographic of conscious consumers [139].

The growth of RIT practices among the leading technology companies reflect an interplay of increasing societal, regulatory, innovative, and ethical pressures. For the private sector, RIT is not just a moral or ethical consideration—it is a strategic imperative. Integrating the RIT concept into corporate missions and values ensures that companies remain resilient, adaptable, and successful in a rapidly evolving technological landscape, all while contributing positively to society and the environment [140].

6. Conclusions

Compared with previous studies, this paper pioneers the exploration of the emerging topic of RIT from an enterprise perspective, especially drawing more practical insights from leading technology companies worldwide. This paper reveals that leading high-tech companies, so-called tech giants, have shifted their attention towards RIT, and their main RIT policy focus is AI technology. The most common policy areas are trustworthiness and acceptability of technology, and the most absent area related to the technology is affordability. Nevertheless, sustainability considerations are rarely part of RIT policy. The findings of this paper illuminate these technology giants' understanding of weaving the RIT concept into their innovation practices, thereby aligning their marketable products and services with this concept. The main contribution of this paper is to construct a holistic and actionable RIT assessment framework by merging these corporate insights with established viewpoints from the policy community and academia.

This framework (Figure 5 and Table A1) provides a systematic approach to holistically evaluate technological outcomes against a broad spectrum of responsible innovation principles. By transforming an abstract concept into specific objectives and statements, the framework operationalises the goals of RIT, making them more actionable and measurable within organisations. Moreover, this paper advocates that by integrating the RIT concept into their corporate missions, values, and overarching strategic visions, companies can enhance their resilience, adaptability, and success amidst the dynamic technological landscape, ultimately fostering positive impacts on our cities and broader societies [141,142].

While the insights from this research offer some value, it is essential to acknowledge certain inherent limitations. This study applied content analysis, which is inherently exploratory but somewhat contingent on the authors' interpretative judgments. Its scope was confined to publicly available corporate documents and focused solely on the technosphere, which may limit its broader applicability. Some work-in-progress RIT guidance or some insights from other fields may have been omitted. Additionally, this study may have inadvertently excluded insights from diverse or non-listed companies by centring on the top listed global technology companies by market capitalisation. Nonetheless, given that the chosen technology companies are the most influential market leaders globally, they offer a representative insight into prevailing trends and dominant perspectives on the RIT discourse.

Despite these limitations, this research study establishes a foundation for the discourse on 'being responsible' within the technosphere. In particular, we developed a more practical and detailed framework, which can serve as a tool for governments, industries, practitioners, researchers, and other stakeholders to evaluate whether the technological outcomes are responsible. The topic of responsible research in the technosphere is still growing, and significant gaps need to be bridged. This paper suggests that future research should delve deeper from an enterprise perspective because the private sector plays a pivotal role in innovation practices. Additionally, further investigations from a user/customer standpoint are necessary to ensure that enterprise propositions align with genuine societal expectations. The following issues/questions are important for prospective research to focus on and address:

- Discrepancies in RIT considerations: Why or what are some key considerations of RIT, which the academic community and user groups have emphasised, rarely mentioned, and discussed by high-tech companies?
- RIT and corporate social responsibility: How do high-tech companies view the relationship between responsible innovation and corporate social responsibility?
- Influences on RIT guidance: Do internal and external pressures directly influence how high-tech companies shape their RIT guidance, and if so, how? How do collaborations with various stakeholders and vendors in a business network (e.g., in the IoT and IIoT contexts) affect the focal organisation's RIT policies?
- Comparative perspectives on RIT: What are the differences or priorities between users' expectations for RIT and the viewpoints high-tech companies, academia, and the policy community advocate?

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Appendix A

Table A1. Responsible innovation and technology assessment framework.

Acceptability Goals							
Equitability Considerations			Scale				
	Objectives	**Statements**	**Low**	**Medium-Low**	**Medium**	**Medium-High**	**High**
OBJ 1	Avoid bias	Does not create, reinforce, or propagate harmful or unfair biases in all stages of innovation and technology practice, from design to deployment and beyond.	□	□	□	□	□
OBJ 2	Guard against discrimination	Upholds the rights of all individuals and groups, embraces the full spectrum of social diversity, and actively prevents any form of discrimination.	□	□	□	□	□
OBJ 3	Strive for fairness	Proactively identifies and eliminates obstacles to ensure fair treatment for all and empower every individual equally through innovation and technology.	□	□	□	□	□

Table A1. *Cont.*

Acceptability Goals							
	Ethics considerations				**Scale**		
	Objectives	**Statements**	**Low**	**Medium-low**	**Medium**	**Medium-high**	**High**
OBJ 4	Human value-based design	Prioritises human values and morals in the innovation process, ensuring that technological outcomes meet functional requirements and align with broader ethical and societal norms.	□	□	□	□	□
OBJ 5	Human-in-the-loop mechanism	Embeds appropriate human oversight and intervention into decision-making processes to balance efficiency with ethical considerations.	□	□	□	□	□
OBJ 6	Respect and enforce privacy	Incorporates privacy principles at every stage of the innovation lifecycle, ensuring that innovation and technological outcomes consistently prioritise and protect user privacy.	□	□	□	□	□
	Harmlessness considerations				**Scale**		
	Objectives	**Statements**	**Low**	**Medium-low**	**Medium**	**Medium-high**	**High**
OBJ 7	Harmless to environment	Ensures respect and protection of the environment, avoiding practices that lead to environmental degradation or the corruption of natural resources.	□	□	□	□	□
OBJ 8	Harmless to individual	Does not lead to any harm against any individuals, including physical and psychological harm.	□	□	□	□	□
OBJ 9	Harmless to society	Minimises adverse impacts on society and commits to the harmonious progress of technology and society.	□	□	□	□	□
Accessibility goals							
	Adaptability considerations				**Scale**		
	Objectives	**Statements**	**Low**	**Medium-low**	**Medium**	**Medium-high**	**High**
OBJ 10	Flexible in nature	Allows individual modification or replacement and can seamlessly operate with other systems to ensure compatibility and ease of integration.	□	□	□	□	□
OBJ 11	Future-proof design	Remains adaptable in the face of evolving socio-technical challenges and paradigms and continues to serve intended purposes throughout their lifecycle.	□	□	□	□	□
OBJ 12	Universal access	Ensures accessibility for all individuals, irrespective of differences in physical ability, technological, cognitive, or actual usage context.	□	□	□	□	□
	Affordability considerations				**Scale**		
	Objectives	**Statements**	**Low**	**Medium-low**	**Medium**	**Medium-high**	**High**
OBJ 13	Cost-effective solution	Provides cost-effective solutions or alternatives to reduce economic disparities in technology adoption.	□	□	□	□	□
OBJ 14	Financial feasibility	Reduces costs to allow broad population segments to access and benefit from innovation and technological advances without negative financial implications.	□	□	□	□	□
OBJ 15	Value for money	Offers genuine value, ensuring that users receive meaningful benefits or solutions that justify the costs, promoting long-term adoption and utility.	□	□	□	□	□
	Inclusiveness considerations				**Scale**		
	Objectives	**Statements**	**Low**	**Medium-low**	**Medium**	**Medium-high**	**High**
OBJ 16	Cultural and contextual sensitivity	Respects shared values while remaining sensitive and attuned to the nuances of diverse cultural norms and contexts.	□	□	□	□	□
OBJ 17	Diverse representation	Ensures marginalised or underrepresented groups are included and have representation in innovation and technology practices.	□	□	□	□	□
OBJ 18	Localisation-friendly	Localises to match local customs, languages, and preferences, ensuring relevance and acceptance in different geo-cultural contexts.	□	□	□	□	□
Alignment goals							
	Deliberateness considerations				**Scale**		
	Objectives	**Statements**	**Low**	**Medium-low**	**Medium**	**Medium-high**	**High**
OBJ 19	Define the purpose	Before taking any initiative or action, clarifies and articulates the intended purpose to ensure alignment with overall goals and values.	□	□	□	□	□
OBJ 20	Proactive risk assessment	Anticipates potential negative outcomes, challenges, or pitfalls, and designs strategies to mitigate or avoid them.	□	□	□	□	□

Table A1. *Cont.*

Acceptability Goals							
OBJ 21	User relevance	Gains a deep understanding of the users' needs, preferences, and challenges to ensure the solutions provided are directly relevant to and satisfy the end-user's needs.	☐	☐	☐	☐	☐
Meaningfulness considerations							
	Objectives	**Statements**	**Low**	**Medium-low**	**Scale Medium**	**Medium-high**	**High**
OBJ 22	Realise human potential	Unlocks humanity's potential, empowering individuals to address complex challenges effectively with increased capability through complementary collaboration with technology.	☐	☐	☐	☐	☐
OBJ 23	Social license to operate	Strives for continuous community recognition, emphasising legitimacy, trust, and ethical alignment beyond mere regulatory compliance.	☐	☐	☐	☐	☐
OBJ 24	Socially beneficial	Promotes human welfare for both current and future generations, fostering growth, prosperity, and positive societal outcomes.	☐	☐	☐	☐	☐
Sustainability considerations							
	Objectives	**Statements**	**Low**	**Medium-low**	**Scale Medium**	**Medium-high**	**High**
OBJ 25	Commitments to climate change	Targets a reduction in greenhouse gas emissions and prevention of waste generation, supporting global efforts to adapt to and mitigate climate change.	☐	☐	☐	☐	☐
OBJ 26	Design for longevity	Ensures resources invested in creating products or solutions provide value over the long term and contribute to more sustainable and resilient societies.	☐	☐	☐	☐	☐
OBJ 27	Eco-friendly design	Incorporates environmental considerations starting from the design phase to ensure products or solutions are eco-friendly throughout their lifecycle.	☐	☐	☐	☐	☐
Trustworthiness goals							
Explainability considerations							
	Objectives	**Statements**	**Low**	**Medium-low**	**Scale Medium**	**Medium-high**	**High**
OBJ 28	Comprehensive explanation	Consistently provides clear and understandable interpretations across a range of inputs and scenarios, rather than being limited to specific instances or datasets.	☐	☐	☐	☐	☐
OBJ 29	Interrogable justification	Provides valid and clear reasons for decisions, operations, or predictions, aligned with pre-defined objectives and standards.	☐	☐	☐	☐	☐
OBJ 30	Intuitive interpretation	Presents operations and outcomes in a manner that is immediately comprehensible to users, irrespective of their technical expertise.	☐	☐	☐	☐	☐
Security considerations							
	Objectives	**Statements**	**Low**	**Medium-low**	**Scale Medium**	**Medium-high**	**High**
OBJ 31	Data security governance	Adopts ethical, safe, and regulatory-compliant data management mechanisms, ensuring security of organisational data and stakeholders' privacy, and upholding trust amidst innovation practices.	☐	☐	☐	☐	☐
OBJ 32	Digitally secure	Establishes systematic measures to protect digital assets, data, and user privacy, ensuring user trust and building a resilient digital ecosystem.	☐	☐	☐	☐	☐
OBJ 33	Physically secure	Implements tangible measures to protect hardware and data storage, ensuring operational continuity and guarding against physical threats to innovation and digital ecosystems.	☐	☐	☐	☐	☐
Transparency considerations							
	Objectives	**Statements**	**Low**	**Medium-low**	**Scale Medium**	**Medium-high**	**High**
OBJ 34	Appropriate disclosure	Transparently discloses issues and matters that substantially affect stakeholders, equipping those engaging with innovation and new technologies with comprehensive information.	☐	☐	☐	☐	☐
OBJ 35	Aware of interaction	Ensures users are consistently informed about their interactions with intelligent systems to promote user autonomy and prevent misuse or unintended consequences.	☐	☐	☐	☐	☐
OBJ 36	Openness of structure	Existence of architecture, training data, algorithms, and operational works that are open, clear, and available for review.	☐	☐	☐	☐	☐

Table A1. *Cont.*

Acceptability Goals							
Well-governance goals							
	Accountability considerations				**Scale**		
	Objectives	**Statements**	**Low**	**Medium-low**	**Medium**	**Medium-high**	**High**
OBJ 37	Redress and remediation	Establishes procedures to rectify any harm or mistakes, compensating affected parties when necessary.	☐	☐	☐	☐	☐
OBJ 38	Responsibility attribution	Clearly identifies parties responsible for decisions, outcomes, or errors arising from the innovation and technology practices.	☐	☐	☐	☐	☐
OBJ 39	Traceable records	Maintains detailed records of decisions, justifications, processes, and outcomes, and ensures the records are accessible to relevant stakeholders.	☐	☐	☐	☐	☐
	Participation considerations				**Scale**		
	Objectives	**Statements**	**Low**	**Medium-low**	**Medium**	**Medium-high**	**High**
OBJ 40	Collaborative governance	Embraces a collaborative governance model, which invites diverse stakeholders to jointly shape and monitor innovation practices, ensuring that technological outcomes resonate with and serve the wider public interest.	☐	☐	☐	☐	☐
OBJ 41	Cooperative design	Facilitates co-design sessions to allow potential users and other stakeholders to directly contribute to the innovation's design or refinement.	☐	☐	☐	☐	☐
OBJ 42	Feedback loops	Establishes mechanisms that allow continuous feedback from users and stakeholders to adapt the innovation accordingly.	☐	☐	☐	☐	☐
	Regulatory considerations				**Scale**		
	Objectives	**Statements**	**Low**	**Medium-low**	**Medium**	**Medium-high**	**High**
OBJ 43	Consistent with best practice guidelines	Observes industry-specific best practices, standards, and codes of conduct that might be set by professional bodies or associations.	☐	☐	☐	☐	☐
OBJ 44	Legal compliance	Adheres to both the letter and spirit of global laws and regulations, while ensuring that innovation and technological outcomes remain adaptable to evolving regulatory landscapes.	☐	☐	☐	☐	☐
OBJ 45	Periodic and independent review	Regularly conducts independent reviews of innovation and technology systems and adjusts as needed to ensure they function as intended and to pre-emptively deter misuse.	☐	☐	☐	☐	☐

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