STRATEGY AS A KEY DRIVER OF THE FOURTH INDUSTRIAL REVOLUTION TRANSFORMATION JOURNEY

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ABSTRACT

With the advent of the Fourth Industrial Revolution (4IR), many industries find themselves having to identify, select, acquire, exploit, and protect their 4IR technologies. However, 4IR technologies are unique when compared with those of the preceding industrial revolutions, in that they are evolving at an exponential rate, and they are complex because they integrate the physical, digital, and biological spheres. Owing to the 'newfangledness' of 4IR, limited empirical references, the agility of 4IR technologies' encroachment, rapid technological changes, high levels of uncertainty, the premise that 4IR induces radical changes to business models, and the realisation that 4IR transformation has long-term consequences for businesses, there is a need for businesses to adopt 4IR transformation using a strategic management approach. The main objective of this paper is to report the findings from an integrative literature review to determine what existing systematic approaches different industries and businesses follow to formulate 4IR technology/transformation strategies. The findings of this study outline some important key principles underlying the formulation of 4IR transformation strategy.

OPSOMMING

Met die koms van die Vierde Industriële Revolusie (4IR) vind baie nywerhede dat hulle hul 4IR-tegnologie moet identifiseer, kies, bekom, ontgin en beskerm. 4IR-tegnologieë is egter uniek in vergelyking met voorafgaande industriële revolusies deurdat die tegnologieë teen 'n eksponensiële tempo ontwikkel, en kompleks is omdat hulle die fisiese, digitale en biologiese sfere integreer. As gevolg van die 'nuutheid' van 4IR, beperkte empiriese verwysings, die behendigheid van 4IR-tegnologieë se indringing, vinnige tegnologiese veranderinge, hoë vlakke van onsekerheid, die uitgangspunt dat 4IR radikale veranderinge aan sakemodelle veroorsaak, en die besef dat 4IR-transformasie lank-termyngevolge vir besighede, is daar 'n behoefte vir besighede om 4IR-transformasie aan te neem deur 'n strategiese bestuursbenadering te gebruik. Die hoofdoel van hierdie artikel is om die bevindinge van 'n integrerende literatuuroorsig te rapporteer om te bepaal watter bestaande sistematiese benaderings verskillende industrieë en besighede volg om 4IR-tegnologie/transformasiestrategieë te formuleer. Die bevindinge van hierdie studie skets 'n paar belangrike sleutelbeginsels onderliggend aan die formulering van 4IR-transformasiestrategie.

1.   INTRODUCTION

Many manufacturing industries, in response to common challenges such as high operating costs (leading to relatively low profit margins), high customer expectations and demands, triple bottom line expectations, health and safety issues of its workers, and so forth, have begun to adapt to the Fourth Industrial Revolution (4IR) landscape. The definitions and paradigms of the 4IR will be addressed in detail later in this paper.

The 4IR is embraced on the premise that 4IR transformation will present new opportunities to manufacturing industries, such as fully integrated value chains, increased efficiency and higher quality across the value chain, reduced resource input, an improved competitive position, and optimal business activities [1], [2], [3], [4], [5], [6]. These endeavours entail, among other things, acquiring 4IR technologies, investing in 4IR-enabling infrastructure, ad modifying and upgrading existing systems to be compatible with 4IR technological innovation.

It has been observed that the 4IR transformation affects all spheres of business organisations, current and future business models, and ways of running business processes, ecosystems, services, and products [3], [7]. Second, 4IR technologies directly affect companies' competitiveness. It should be noted that 4IR is not only about the use of new technologies, but is also about changes to key business elements, such as strategies, business models, and organisational structures and cultures [8].

However, the 4IR causes fundamental changes in conventional business practices with the use of digital technologies [9]. The changes brought about by the 4IR are not only to processes, but to many facets of a company such as its organisational culture, relationships, value creation, customer expectations, and market position [10]. To stay competitive and to avoid disruption by a new market entrant, incumbent companies need to adapt and even remodel their core business models in alignment with the trend towards digitalisation [4].

The 4IR brings technological discontinuities and high levels of uncertainty. According to [11], discontinuities bring at least three challenges to companies; they challenge how the company creates value, how it captures value, and how it affects value delivery. However, the decisions about 4IR transformation have long-term multifunctional consequences for companies, and will often impact a lot of stakeholders.

In the age of 4IR, it is not enough for companies just to respond to changes; they should anticipate them and stimulate innovative approaches through planning and strategic management. Most important to note is that the 4IR transformation process involves large amounts of a company's resources (such as money), and cannot be done without taking into account the company's business environment. That is why companies that wish to adopt and embrace 4IR technologies successfully should formulate and implement 4IR transformation strategies.

One of the cited causes of the failure of 4IR adaptation and implementation endeavours is a lack of strategy [12], [13]. According to [14], the lack of clear vision and objectives leads to the failure of 4IR initiatives. Thus, there is a need for a new approach to technology strategy, with a full consideration of the dynamics (shrunken technology cycles and agility) and turbulence that are inherent in 4IR technologies.

The 4IR transformation strategy will essentially serve as a functional strategy that is informed by both corporate and business strategies. The 4IR technology/transformation strategy is important for protecting manufacturing companies from sudden technology leaps and discontinuities. According to [15], a digital business strategy has become a management priority for companies in several industries, and many companies have started establishing a guiding framework for value creation and value capture with digital resources.

The 4IR transformation strategy will serve as a structural and formal plan that will direct manufacturing companies throughout their 4IR transformation journeys. According to [16], an effective strategy is the most critical challenge that organisations can face during the 4IR process. Also, [17] asserts that 4IR business transformation can only be successful if there is well-founded strategy and leadership from the company.

Many authors have emphasised the importance of a technology strategy and the competitive advantages that it brings to the company's quest for success [18], [19], [20], [21]. According to [22], there is still a lack of studies on the guidelines for the successful implementation of 4IR transformation. It is on that basis that [23] conclude that there is still limited scholarly work exploring the practical implementation of 4IR transformation processes.

In the absence of guidelines, frameworks, and strategic approaches for 4IR transformation processes, companies will be engulfed in a state of uncertainty that could lead to reactive rather than proactive approaches to the technological changes brought by the 4IR. The current challenge for companies is that, given the 'newfangledness' of the 4IR, the limited number of empirical references, and the agility of 4IR

technologies' encroachment, there is no framework to guide companies in the formulation and implementation of 4IR transformation.

Thus, the main objectives of this study are:

1. To provide an understanding of the role played by strategy in ensuring a successful 4IR transformation journey.

2. To identify, based on the literature, some of the key principles underlying the formulation of a 4IR strategy.

3. To discern some of the critical steps in a 4IR transformation strategy.

This paper comprises a brief description of the research methodology used, the findings and a discussion of them, and conclusions and recommendations for future work.

2. RESEARCH METHODOLOGY

Considering that scholarly work on the 4IR is still evolving, this study is a hybrid of both exploratory research and integrative research methods. Detailed reasons for choosing the two research methodologies are outlined below.

2.1. Exploratory research methodology

This exploratory research approach was chosen to help discover ideas about and insights into the 4IR transformation strategy using qualitative means. According to [24], exploratory research is a form of research that generates initial insights into the nature of an issue, and develops questions to be investigated by more extensive studies, while [25] posits that exploratory studies are valuable ways to understand what is happening, to seek new insights, to ask questions, and to assess a phenomenon in a new light.

According to [26], exploratory studies assist in formulating problems more precisely, in clarifying concepts, gathering explanations, gaining insights, eliminating impractical ideas, and formulating hypotheses (but does not seek to test them). Many researchers have highlighted that, in an exploratory study, a large amount of unstructured information is collected in order to explore a new topic, or to work on new topics about which very little information is available, and to gain a broad understanding of a situation [27], [28 [29], [30].

Some scholars have also posited that exploratory research does not only apply to new concerns, but can also be used to become familiar with topics with the intention of gaining an initial understanding of the topic [31], [32].

2.2. Integrative literature review method

Part of the research methodology used in this study was an integrative literature review. The integrative literature review is a particularly broad way to study the existing literature because it can encompass a broad array of scholarly literature — empirical, non-empirical, conceptual, and theoretical — to address a particular phenomenon [33]. According to [34], an integrative literature review is a distinctive form of research that generates new knowledge about the topic being reviewed.

The main objective of the integrative literature review on a new phenomenon in the field is to generate an initial holistic conceptualisation of the phenomenon [35]. According to [36], the integrative literature review method is the only approach that allows for the combination of diverse methodologies (for example, experimental and non-experimental research) and, most importantly, it helps to identify gaps in one's knowledge of a particular phenomenon [37].

According to [38], integrative literature reviews can be used to assess, critique, and synthesise many types of topics, whether emerging, new, or mature. This approach was fit for the purpose of this study, as digital transformation, or the 4IR phenomenon, is relatively new and emerging.

The research questions for an integrative literature review can be narrow or broad, depending on the objective of the study. The literature search strategy need not be systematic.

For this study, taking into consideration that digital transformation/4IR is a new and emerging topic, the intent was to understand and critique initial conceptualisations and theoretical frameworks rather than to review old theoretical models and frameworks.

2.3. Research questions

The research questions that were to be answered in the light of the objectives are listed below:

1. Why is a strategy important for the 4IR transformation journey?
2. What are some of the key principles underlying the formulation and implementation of a 4IR transformation strategy?
3. What critical steps are involved in the formulation of a 4IR transformation strategy?

3. FINDINGS AND DISCUSSION

Various publications, such as journal articles, books, and other relevant scholarly works, were scrutinised and analysed in depth, and were divided according to their relevance to the respective research questions. Given the nature of the study as being based on secondary data, the interpretation of results was descriptive, and no statistical tools or analysis were applied.

3.1. The 4IR (4IR)

Since the study was about strategy in the 4IR, it was prudent first to get an overview of what the 4IR is about and to understand how it differs from the preceding industrial revolutions. It should be noted that, although many authors have defined and described the 4IR from different perspectives, there appears to be a good convergence in their definitions and descriptions.

Authors such as [39] and [40] have defined 4IR as the use of new digital technologies (social media, mobile, analytics, or embedded devices) to enable major business improvements (such as enhancing customer experience, streamlining operations, or creating new business models). For [41], the 4IR is defined as the use of digital technologies radically to improve a company's performance through the use of new digital technologies such as social media, mobile devices, analytics, or embedded devices to enable major business improvements such as enhancing the customer experience, streamlining operations, or creating new business models [42], [43]. It also been argued by [44] that the 4IR is concerned with the changes that digital technologies can bring about in a company's business model, resulting in changed products or organisational structures or in the automation of processes.

[45] have described the 4IR as changes and transformations that are driven by and built on a foundation of digital technologies. In an enterprise, the 4IR is defined as an organisational shift to big data, analytics, and cloud, mobile, and social media platforms. As organisations are constantly transforming and evolving in response to a changing business landscape, digital transformation is the changes that are built on the foundation of digital technologies, ushering in unique changes in business operations, business processes, and value creation. [46] assert that the 4IR encompasses both process digitisation with a focus on efficiency and digital innovation with a focus on enhancing existing physical products with digital capabilities.

[47] argue that the 4IR makes full use of emerging technologies and the rapid development of machines and tools to cope with global challenges to improve industry levels. The main concept of the 4IR is to use -advanced information technology to deploy Internet of Things (IoT) services. Production can run faster and more smoothly with minimum downtime by integrating engineering knowledge. Therefore, the product that is built will be of better quality, and production systems will be more efficient, will be easier to maintain, and will achieve cost savings. An argument by [48] is that the 4IR involves leveraging digital technologies to enable major business improvements, such as enhancing the customer experience or creating a new business model.

According to [49], the 4IR is surrounded by a huge network of advanced technologies across the value-chain. Automation, artificial intelligence robotics, the Internet of Things, and additive manufacturing are bringing in a brand-new era of manufacturing processes. The boundaries between the real world and virtual reality are becoming blurred, and giving rise to a phenomenon known as cyber-physical production systems (CPPS).

The argument of [50] is that the 4IR can be classified into three components: horizontal, vertical, and engineering integration. The combination of these components results in the concept of a new type of worldwide value chain network that allows for hierarchical sub-systems to produce an easy-to-configure and high-flexibility production line.

The view of [51] is that the 4IR is mostly about the impact of information technology (IT) on an organisation's structure, routines, information flow, and ability to accommodate and adapt to IT. In this sense, the 4IR emphasises more the technological root of IT and the alignment between IT and businesses, leading to the extended use of advanced IT, such as analytics, mobile computing, social media, or smart embedded devices, and the improved use of traditional technologies, such as enterprise resource planning (ERP), to enable major business improvements [52].

Figure 1 shows the evolution of the industrial revolutions from the First Industrial Revolution to the 4IR, which is the focus of this study. It shows that the Third Industrial Revolution was mainly manifested in the introduction of automation of equipment and processes, computerisation, electronic devices, nanotechnology, biotechnology, micro-electronics, telematics integrated systems, and so forth. The Third Industrial Revolution essentially drove a rapid expansion into automated production and services.

As can be seen in Figure 1, the 4IR is characterised by a convergence of different technologies, seamlessly merging the physical, digital, and biological spheres. Essentially, the 4IR is technology driven. As stated by [53], the 4IR is the implementation of the smart factory to provide smart products and services that meet consumers' individual needs. It should be noted that the 4IR comes with both risks to and opportunities for companies. The strategic issue comes from the risk associated with adaptation and implementation, capturing value, and the inadequacy or relevance of existing organisational capabilities.

In comparison with the preceding industrial revolution, the 4IR is advancing at an exponential and non-linear pace. According to [54], the breadth and depth of the 4IR is unique because it builds not only on the technological infrastructure developed during the Third Industrial Revolution and on the vast troves of data that now exist, but also on the pervasiveness of the internet platforms whose business models are now impacting all markets and industries with varying degrees of disruption. It is also important to note that the 4IR has an impact on all systems, and thus transforms entire companies, industries, countries, and societies. The European Commission has already started talking about the Fifth Industrial Revolution (5IR), although there is not yet much published scholarly work on it.

The 4IR also describes the triggering of tactical or strategic business moves by data-driven insights, and the launch of digital business models that allow new ways to capture value. The argument of [55] is that the 4IR is a higher-level phenomenon that disrupts the competitive environment and demands a response from companies.

Considering the disruptive nature of the 4IR's technological innovations, companies must formulate and implement 4IR transformation strategies to remain competitive. A 4IR transformation strategy would help to identify, understand, and forge the fusion between a conventional organisational strategy and the 4IR's technological innovations.

A 4IR transformation strategy is a blueprint that supports companies in governing the transformations that arise from the integration of digital technologies, as well as in their operations after a transformation [56].
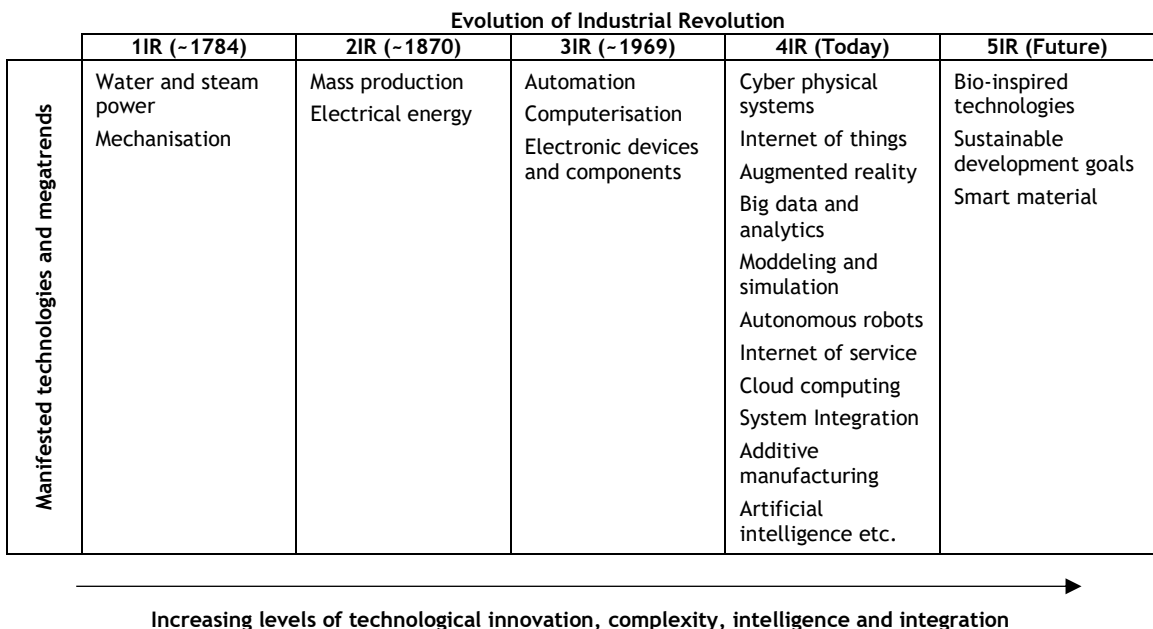
Evolution of Industrial Revolution

	1IR (~1784)	2IR (~1870)	3IR (~1969)	4IR (Today)	5IR (Future)
Manifested technologies and megatrends	Water and steam power Mechanisation	Mass production Electrical energy	Automation Computerisation Electronic devices and components	Cyber physical systems Internet of things Augmented reality Big data and analytics Moddeling and simulation Autonomous robots Internet of service Cloud computing System Integration Additive manufacturing Artificial intelligence etc.	Bio-inspired technologies Sustainable development goals Smart material

Increasing levels of technological innovation, complexity, intelligence and integration

Figure 1: Evolution of the four industrial revolutions

3.2. Why is strategy important for 4IR transformation?

With the advent of the 4IR, many industries find themselves having to embrace a technology management approach to identify, select, acquire, exploit, and protect 4IR technologies. This approach is called the technology management process framework, and is illustrated in Figure 2.

According to [57], [58], and [59], 'identification' in the technology management framework entails developing an awareness of all the technologies that already are, or that in the near future might be, important to the company. This awareness is achieved through routine and systematic scanning of existing and emerging technologies. Figure 2 shows the activities and complexities associated with the technology management that is fully applicable to the 4IR's technological innovations.

'Selection' entails the choice of technologies that a company decides to support and promote in the organisation, while 'acquisition' is about the decisions about the appropriate ways to acquire selected technologies and to embed them in the company.

The 'exploitation' aspect of the technology management framework is about a systematic conversion of technologies into marketable products and services. Finally, 'protection' involves the preservation of the knowledge and expertise that are embedded in products, services, and manufacturing systems.
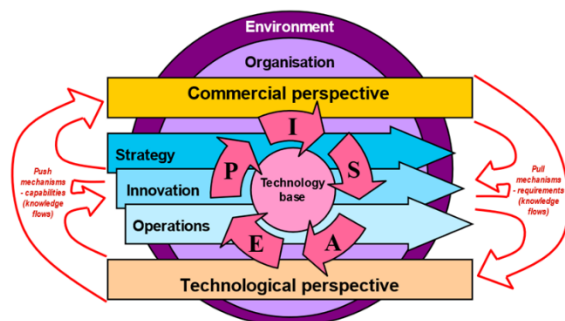

Figure 2: Technology management framework [58]

The 4IR transformation is becoming a way for companies to reach their envisioned global competitiveness goals and optimum value creation. However, the 4IR is different from the preceding industrial revolutions with respect to the agility of changes, the market and rules of competition, the distribution of value creation and value capture, stakeholder interfaces, and technological capabilities and integration.

In terms of the agility and dynamics of competition, the 4IR phenomenon blurs and dissolves existing industry boundaries, leading to cross-industry competition [60], [61], leaves companies less time to respond to disruptive threats [62], demands faster decision-making and product launches [63], and results in greater innovation network heterogeneity [64].

The approach to value creation and capture in the 4IR landscape is different from that in the preceding industrial revolutions, in that value, by and large, is co-created and captured in a series of partnerships in a value network [65]; in some instances, customers are involved in the co-creation of products with manufacturers [66], [67], and the customer, not the manufacturer, determines the dimensions of value that are critical [68].

The stakeholder interface in the 4IR phenomenon is characterised by instant access to data, thus assisting in reducing information asymmetries among stakeholders [69], and the intermediaries are replaced by multi-sided digital platforms and networks that match consumers and manufacturers [63], [65], [70].

With respect to technological capabilities and integration, IT flexibility is critical [71] for the creation of new enterprise platforms [66], relatively higher computing power, data storage, and information distribution of cross-boundary digital technologies [72], [73]. Data is one the most important parameters of the 4IR era [67], [74].

Thus, as many industries embed the 4IR transformation into their value chains, they should consider that the technology management of 4IR technologies is utterly different from that in the preceding revolutions, in that they are new, complex, and integrated, and affect the company's entire value chain. Moreover, the 4IR is characterised by a blurring of the barriers between people, businesses, and things. It has also been observed that 4IR transformation could give rise to completely novel, revolutionary approaches [75]. In addition, 4IR technologies are perceived as a potential threat to organisations' well-being if they are not managed strategically [76], [77].

To highlight the disruptive nature of the 4IR, [55] focuses on the 4IR phenomenon as a process in which digital technologies create disruptions that trigger strategic responses from organisations that seek to alter their value creation paths while managing the structural changes and organisational barriers that affect the positive and negative outcomes of this process.

The 4IR technologies are novel to existing companies, which means that their adaptation and implementation comes with radical technological innovations. This implies that, to incorporate the novel technologies of the 4IR into their value chains, companies will need an absorptive capacity and new capabilities. [78] argues that many decision-makers sense the technological changes that are brought by 4IR and the resulting shifts in the competitive context, which could have a profound impact on their organisations; but it is not yet clear how they should prepare for these threats, or what steps would be needed to respond appropriately to them.

All companies expect major long-term gains in efficiency and productivity from adopting 4IR technologies [79]. However, these gains are linked to high risks (particularly financial risks) – hence the need for a strategic approach [56]. [44] argue that, at the organisational level, companies must innovate with 4IR technologies by coming up with strategies that embrace the implications of the 4IR and drive better operational performance. In other words, 4IR transformation requires rethinking – or, at the very least, reworking – existing business models and innovation approaches.

The 4IR transformation, being technologically radical, is inherently characterised by relatively high levels of uncertainty; thus it could be risky to the organisation if not managed with appropriate technology management tools. Several authors have submitted that uncertainty is prevalent in the 4IR context, and that companies cannot easily know what to do owing to the 'newfangledness' of the 4IR phenomenon [80], [81].

Also, it is important to note that 4IR transformation is not a linear process, as it involves different possible causes of action [46]. [63] assert that 4IR is not about a single technology, but about a suite of information, computing, communication, and connectivity.

4IR innovations affect organisations' strategy, processes, products, and services; so companies need to manage them using both traditional and technology management guidelines. An argument of [82] is that technology decisions are inherently strategic because they span long time frames, and deploy significant resources that are often irreversible (or rather, are difficult to change once commitments are made); and the technology inherently competes for resources in a company.

According to [40], 4IR is more than just the application of technologies, as it affects companies' people, products and services, and processes. Most importantly, 4IR transformation is a continuous process that requires continual adjustments of processes, services, and products to external needs [83].

That is why the advent of the 4IR should be assimilated to a strategic inflection point (SIP) for many industries. The suggestion of [84] is that SIP is a stage in the life of a business when its fundamentals are about to change. That change could mean an opportunity to rise to new heights – or it might just as likely signal the beginning of the end. Essentially, SIP represents what happens to a business when a major change (particularly technological) takes place in its competitive environment. Management tools, strategies, and techniques that were effective in the past might no longer be sufficient to keep the company competitive.

SIPs are critical points in a company's strategic journey, as it comes with a phenomenon known as 'strategic dissonance'. According to [85], strategic dissonance is a sign of distress that signals that fundamental change is about to happen in an organisation or industry, and is characterised mainly by a divergence between its current strategic intent and the strategic actions in the organisation.

When a company finds itself experiencing strategic dissonance, it must endeavour to discern the newly emerging strategic picture and to provide a framework through which the divergence between strategic intent and strategic action could be countered and a new strategic direction formulated.

Figure 3 shows an SIP applied to the advent of the 4IR. It can be seen that, beyond the SIP, companies without a 4IR transformation strategy could experience disastrous consequences for their profitability, growth, and sustainability performance characteristics. However, [86] posit that an SIP could present opportunities for companies Rwith the new technological changes; but it could be catastrophic if not attended to.

According to [84], SIPs are caused by technological changes (such as those of the 4IR), and are more than just technological changes: they are full-scale changes in the way business is conducted, so that simply adopting new technology is no longer sufficient.
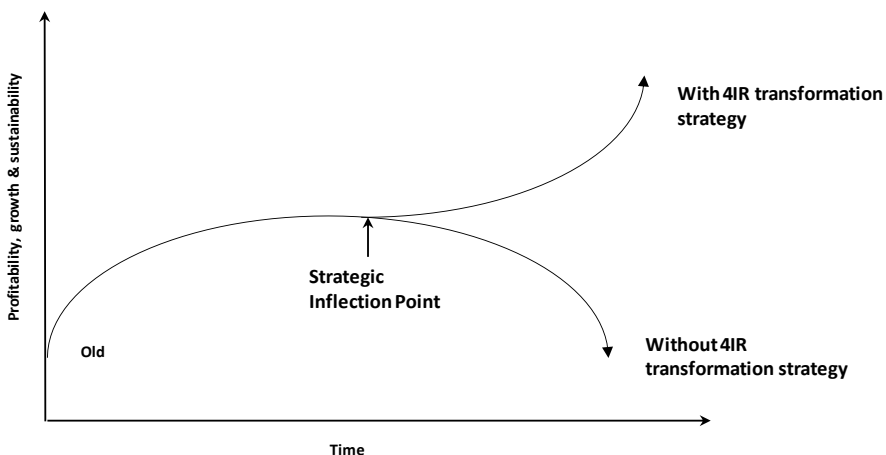

Figure 3: The strategic inflection point (SIP) applied to 4IR (adapted from [87])

From the above discussion of the 4IR phenomenon and its disruptive nature for companies, the high levels of technological uncertainty it brings, and how it affects companies' competitiveness, the importance of managing it using a strategic technology management approach is clear. Strategy is concerned simply with a company's effort to maintain profitable growth in its environment [85].

The 4IR transformation is not an easy exercise, especially in the absence of empirical guideposts such as frameworks and strategies. As [18] warns, for companies to gain comparative advantage by adopting complex, costly, and rapidly changing technology, they need to manage technology strategically; hence the need for a 4IR transformation strategy. No matter the motive for technology adoption, there is a risk in adopting 4IR technologies without being guided by a 4IR transformation strategy.

Traditionally, a technology strategy was seen to be crucial in high-technology industries such as computing, aerospace, and biotechnology [19]; however, with the advent of the 4IR phenomenon, a technology strategy is crucial for every company and industry for the sake of their global competitiveness and sustainability.

According to [88], there are critical relationships between the effect of current technology on the strategy of a company, the effect of the current strategy on future technology, and the effect of the current technology on future strategy. They conclude that:

- Current strategy capitalises on current technology
- Current strategy cultivates future technology
- Current technology drives cognition of future strategy

Given the 'newfangledness' of the 4IR phenomenon, the process and activities involved in the formulation and implementation of the 4IR transformation strategy are still not well understood. In addition, there is a lack of research and scientific scholarly work that offers guidelines or a framework for a strategic management approach to 4IR transformation.

Table 1 summarises the common reasons for the importance of a strategy in 4IR transformation.

Table 1: Key reasons for the importance of a strategy in 4IR transformation

Contributing reasons to the importance of a 4IR transformation strategy	Scholarly publications
4IR gives companies less time to respond to disruptive threats	[62]
Demand for faster decision-making and product launches	[63]
The need for a central concept to co-ordinate, prioritise, and implement 4IR transformation	[89]
Response to risks of and opportunities from 4IR technologies	[89]
Requirement by 4IR for co-creation of value among stakeholders	[65], [66], [67], [68]
Increase in innovation heterogeneity from 4IR technologies	[64]
High novelty and revolutionary approaches	[75]
Threat to organisational wellness	[76], [77], [79]
Importance of and access to data and data storage and management	[63], [65], [67], [69], [70], [72], [73], [74]

The common reasons, among others, are to mitigate the threat brought about by 4IR emerging technologies to the wellness of the organisation; to dampen the disruptive nature of 4IR emerging technologies; to ensure the expected agility in decision-making; to mitigate the innovation heterogeneity inherent in 4IR emerging technologies; to embrace the new way of stakeholder involvement (co-creation of value); to appreciate the criticality of data, data storage and management; and strategically to manage the high novelty of 4IR emerging technologies.

In addition, the 4IR technologies bring both risks to and opportunities for industries. However, for companies to realise the opportunities and mitigate the concomitants risks, they need to formulate and implement a 4IR transformation strategy. The 4IR will assist in ensuring a successful adaptation and implementation of 4IR technological innovations and initiatives.

In conclusion, it is apparent from the above discussion that the technological changes brought about by the advent of the 4IR can either break or make an organisation's success and sustainability. A 4IR transformation strategy would help to bring together critical aspects of the organisational and environmental contexts of 4IR technologies, and focus attention on the interaction of all the key dimensions for value creation. It would also help to promote an integrated and integrative view of the company's approach to value creation across its value chain and, most importantly, help companies to deal with the sudden technology leaps and discontinuities brought about by 4IR technologies.

Last, a 4IR transformation strategy could serve as a force that unifies companies' diversified activities and layers of the value chain.

3.3. What are some of the key principles underlying the formulation and implementation of a 4IR transformation strategy?

Strategic decision-making and concomitant strategies in most companies exist in a hierarchy with at least three levels. Figure 4 shows a typical hierarchy of strategies in a company. At the top of the hierarchy is the corporate strategy level, followed by the business unit strategy level, and at the bottom is the functional strategy level [19], [90], [91].

According to [85], corporate strategy reflects what top management has learnt about the basis of the company's past successes and failures in terms of its distinctive competencies, product market position, core values, and long-term objectives. As proposed by [19], corporate strategy in most cases emphasises where the company wants to be at some future point, and selects appropriate ways to bring that about. In addition, [90] highlight that, to a large extent, attitudes at the corporate strategy level reflect the concerns of the stockholders and the society at large. [92] argues that corporate strategy is concerned with the overall purpose and scope of the organisation to meet stakeholders' expectations; and it is at this level that guidance for strategic decision-making throughout the organisation is made.

The business unit level strategy is about translating the statements of direction and intent that are generated at the corporate level into concrete objectives and strategies for individual business units [90]. According to [91], at the business unit level, strategies for how the company should compete with its rivals are formulated, the main goal being to establish a sustainable competitive advantage.
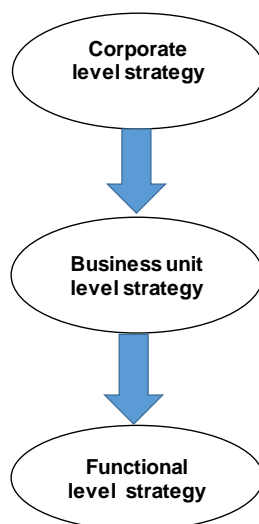
Figure 4: General hierarchy of strategies ([19], [90], [91], [92])

The functional level strategy outlines how different functions of the business support the corporate level and business level strategies. It is about a functional contribution to the achievement of corporate strategy. It is under this level that the technology strategy, particularly the 4IR transformation strategy, will fall. It is at this level where decisions about long-term technological commitments and company technology management approaches are made.

According to [86], all functional level decisions are relatively concrete and quantifiable and receive critical attention and analysis. This is where the 4IR transformation strategy fits, as it is part of how corporate objectives will be achieved. However, since the business unit level strategy essentially assists as a connecting level between the corporate and functional levels, 4IR transformation decisions to a large extent are also part of the business unit level strategy. As argued by [93], an improved link between the business strategy and the technology strategy allows companies to increase their ability to react faster and more effectively to changes in the business environment.

Accordingly, [94] classifies the relationship between the technology strategy and the corporate strategy, and concludes that technology might be an element of reactive strategic planning, or it might lead the strategic planning process proactively, or it might become the driver of the corporate strategy. The appropriate relationship between the 4IR transformation strategy and the corporate strategy could be for the 4IR to form part of the leading drivers of a proactive strategic planning process for the company.

First, it should be highlighted that the 4IR transformation strategy is different from a conventional technology strategy that is undertaken by a company with the intention of building and maintaining a technological position. The latter entails at least a technology audit and assessment (to identify strategic issues), followed by filling the identified gaps. Since the 4IR phenomenon affects many industries, 4IR transformation strategies are not necessarily about being a leader or a follower, but rather about how to adopt and implement 4IR technologies successfully. Second, 4IR transformation strategy does not depend on a single dimension: it includes many dimensions such as IT, information systems (IS), change management strategies, and the components of a business strategy [63], [95].

The 4IR transformation strategy cuts across both the business unit level and the functional unit level. It is at the business unit and functional strategy levels where efficiencies, cost-effectiveness, quality management, and other action-oriented mandates are implemented. It is important to highlight that a 4IR transformation strategy cannot replace or dictate the company's corporate strategy; rather, it should be viewed as one element in an overall competitive strategy, and thus must be reinforced by the actions of other functional units.

A distinctive feature of 4IR technologies is that they constitute 'basic technologies'. According to [96]'s definition, basic technologies are those that the company requires for its survival; in other words, the company's operations depend on them, and without them it would be excluded from the market. Most importantly, 4IR technologies' disruptive nature is an existential threat, not just a future threat, and so companies need to view them as a strategic issue. As argued by [13], 4IR technologies are both game-changing opportunities and existential threats to companies.

However, 4IR transformation is affected by nearly all factors that influence a conventional technology strategy. [97] argue that three factors determine what a company can and cannot do: its resources, its processes, and its values. 'Resources' refers to both tangible and intangible things; and when a company has access to high-quality resources, its chances of coping with disruptive changes are good.

'Processes' refers to patterns of interaction, co-ordination, communication, and decision-making that are used to transform resources into products and services, while 'values' entails the standards by which priorities are set and decisions are made.

In addition, to a large extent the generic determinants of a conventional technology strategy are also applicable to a 4IR transformation strategy (simply because 4IR is about technologies that blur the lines between the digital, physical, and biological spheres). According to [98], the determinants of a technology strategy are technology's evolution, the industry context, strategic action, and the organisational context. The evolutionary factors that shape the creation of a technology strategy include internal and external generative and integrative forces.

It is important to identify and understand the dimensions of a 4IR transformation strategy. According to [56], there are four dimensions of a 4IR transformation: the use of technologies, changes in value creation, structural changes, and the financial aspects. These four dimensions are the basis of a 4IR transformation strategy.

A 4IR strategy will follow a typical technology strategy flowsheet, with some additions, since the 4IR is different from the preceding industrial technological landscapes. The starting point will be to identify and understand the triggers (both internal and external) to adopting 4IR technologies.

The formulation of a 4IR transformation strategy will assist in addressing some of the aspects of the technology management framework, such as the technological, organisational, customer, and environmental perspectives.

Figure 5 shows the key components of a 4IR transformation strategy: the 4IR's emerging technologies, stakeholder requirements, triple bottom line constraints, and the business systems infrastructure. Included in 4IR emerging technologies is big data and analytics. For the 4IR transformation strategy wheel to keep turning, the company needs to have the ability to analyse and handle data using big data analytics and advanced algorithms – that is, the process of storing and examining large volumes of data from various sources and systematically extracting useful information from it. According to [54], big data methodologies have become a key basis of competition, underpinning new waves of innovation.
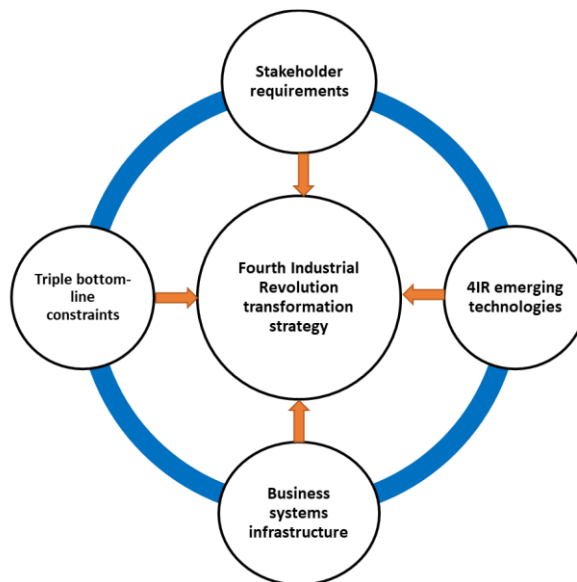

Figure 5: Key components of a 4IR transformation strategy

The biggest challenge for any company is strategically to combine and integrate the key elements of the 4IR for the benefit of the company.

The assertion by [99] is that the 4IR encompasses the digitisation of sales and communication channels, which would provide novel ways to interact and engage with customers, and the digitisation of a firm's offerings (products and services), which replace or augment its physical offerings.

In summary, some key principles underlying the formulation and implementation of a 4IR transformation strategy are the following:

- Strategic decision-making and concomitant strategies in companies exist on at least three levels of hierarchy: the corporate, business unit, and functional levels; and the 4IR transformation strategy cuts through all of those levels.

- There is difference between a conventional technology strategy and a 4IR transformation strategy. The latter is not about being a leader or a follower in technology but rather is about how to adopt and implement 4IR technologies successfully.

- A 4IR transformation strategy cannot be done in isolation from the company's business strategy. It is not a primary strategy, but a strategy that augments the business strategy.

- The formulation and implementation of a 4IR transformation strategy is influenced by critical inputs such as stakeholder requirements, triple bottom line constraints, the business systems infrastructure, and the 4IR's emerging technologies and megatrends.

- A 4IR transformation strategy cannot replace or dictate the company's corporate strategy; however, it should be viewed as one element in the overall company's competitive strategy, and should be re-enforced by the actions of both the business unit and the functional levels.

3.4. What critical steps are involved in formulating a 4IR transformation strategy?

The successful adaptation and implementation of a 4IR transformation strategy is dependent on its alignment with the following dimensions: the use of the correct technologies, structural changes, remodelling of value creation, and the monetary requirements of the 4IR transformation [44], [56], [89], [100], [101], [102].

[17] also asserts that organisational change, technology, and data integration need to be addressed equally for companies to achieve a successful 4IR transformation.

The basic elements of a technology strategy are shown in Figure 6, and consist of strategic diagnosis, formulation of technology strategy, crafting an implementation approach, execution, and control and monitoring. This conventional framework for technology strategy formulation forms the basis for the 4IR transformation strategy formulation. However, a conventional technology strategy management approach might not be adequate, given the technological innovation intricacies associated with a 4IR transformation strategy.
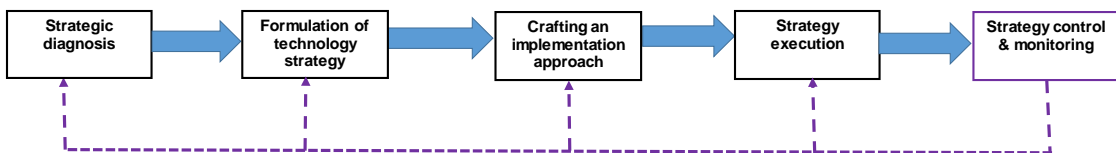

Figure 6: Typical traditional technology strategy formulation (adapted from [82])

Error! Reference source not found. shows a recommended possible approach to formulating a 4IR t ransformation strategy by combing both the conventional technology strategic management approach and proposed modifications to incorporate 4IR technological dynamics. The approach has two concurrent, almost linear, processes that synergise the conventional technology strategy and 4IR transformation approaches.

3.4.1. Conventional technology strategy approach

The first step is for the company to identify and understand its triggers/inducers for it to adopt the 4IR transformation journey. Some of the possible triggers are the pursuit of competitive advantage, the diffusion of 4IR technologies, the emergence of 4IR technologies, the influence of technology-driven industry dynamics, and changes in customer requirements and characteristics.

The second step is for the company to understand and be conversant with the drivers of the 4IR in the context of the external environment (operating, industry, and remote environments). The external environment factors are beyond the company's control, but do influence its choice of direction and action, organisational structure, and internal processes [86].

The third critical step is the application of a technology management framework to link the company's activities to the 4IR transformation strategy. The technology management process framework comprises the identification of technologies, the selection of technologies, the acquisition and assimilation of the selected technologies, the exploitation of technologies to generate benefits for the company, the protection of knowledge and expertise, technology financing, and technology phase-out.

Proposed additions to the conventional strategy approach

4IR implementation strategy

4IR transformation strategy

Alignment

Business re-architectured

Specific 4IR transformation strategies

Organisational analysis (Reference architecture models)
- RAMI 4.0
- IRA
- IBM
- SME
- IMSA
- IVRA etc.

Emergence of 4IR technologies
- Artificial intelligence
- Big data & analytics
- Internet of things
- Advanced robotics
- Additive manufacturing etc.

Conventional strategy management approach

Desired Outcomes
- limproved performance
- New form of value
- Modified business models
- Efficient process
- Smart products

Implementation & execution
- Stakeholder engagement
- Monitoring plans
- Evaluation programs
- Integration of capabilities

Technology management activities
- Technology selection
- Technology acquisition
- Technology development/testing
- Technology exploitation
- Technology financing
- Technology phaseout

Essential Interface

Drivers of 4IR transformation
- Operating environment
- Industry environment
- Remote environment

Triggers / inducers of 4IR transformation
- Competitive advantage
- Diffusion of technologies
- Emergence of technologies
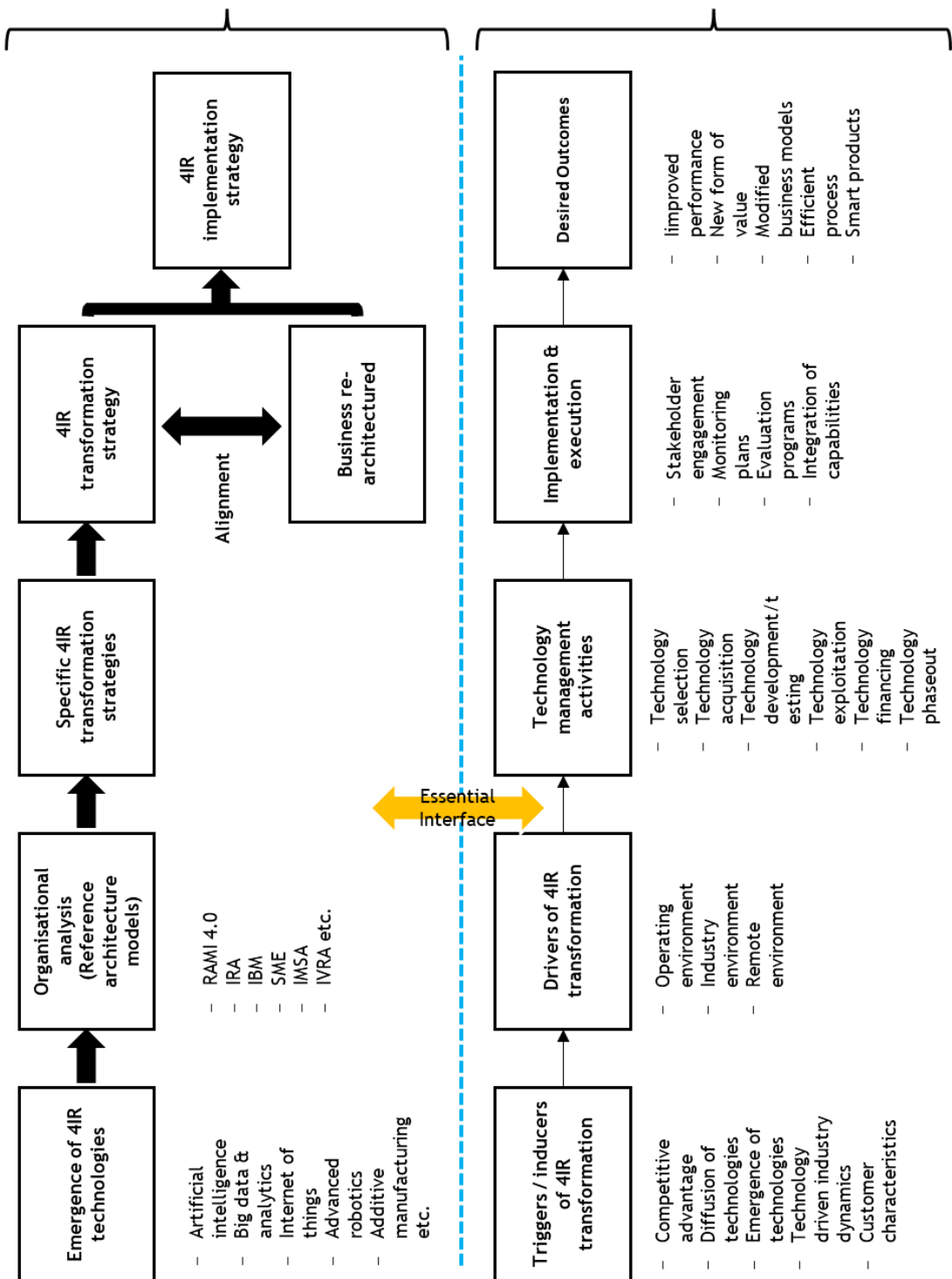- Technology driven industry dynamics
- Customer characteristics

Figure 7: Proposed approach to the formulation of a 4IR transformation strategy

The fourth critical step is the implementation and execution phase of the 4IR transformation strategy. It comprises key aspects such as stakeholder engagement, monitoring plans, evaluation programmes, and the integration of capabilities, policies, and procedure developments. [103] notes that strategy implementation is a process of ensuring that strategies are working in practice.

[104] and [105] posit that the effectiveness of strategy implementation is a critical element in organisational performance and a necessary antecedent to the evaluation of the quality of formulated strategies. [106] asserted that effective strategy implementation is a critical component of organisational success and a potential source of competitive advantage, and is influenced by at least three components: the actions through which managers influence the implementation process, the conditions that are necessary for effective strategy implementation, and the underlying dynamic managerial capabilities.

3.4.2. *Proposed additions to the conventional strategy approach*

First, it should be stressed that there is an essential interface between the proposed 4IR transformation strategy and the conventional technology strategy approach. Thus, the proposed 4IR transformation strategy approach is an additional way to augment the conventional technology strategy management approach.

The proposed 4IR strategy formulation and implementation starts with the emergence of 4IR technologies such as artificial intelligence, big data and analytics, the Internet of Things, the Internet of Services, advanced robotics, additive manufacturing, augmented reality (AR), virtual reality (VR), cloud computing, and cyber security.

The second activity is to do a complete organisational analysis using any of the applicable reference architecture models such as Reference Architecture Model Industry 4.0 (RAMI 4.0), Industrial Value Chain Reference Architecture (IVRA), or Industrial Internet Reference Architecture (IIRA), to understand where in the value chain, life cycle, value stream, or hierarchy levels the identified 4IR technology will add value.

The third activity is to formulate a specific 4IR transformation strategy, informed by the organisational analysis results. It is followed by the formulation of the integrated 4IR transformation strategy, which should be aligned with the business re-architecture strategy.

The final activity is the 4IR implementation strategy, which should also include controls and monitoring.

3.4.3. *Strategic control*

The last critical step in both conventional strategic management and 4IR transformation strategy approaches is strategic control. Strategic control is concerned with tracking the strategy as it is being implemented, detecting problems and changes in its underlying premise, and responding accordingly where necessary [90]. According to [91], strategic control needs to be forward-looking as well as backward-looking, have both internal and external focuses, be able to focus on big issues, be actionable, and be systematic.

Figure 8 shows the potential 4IR strategy controls and their alignment with the respective strategy levels. According to [92], strategic control does not mean just reacting to events after they have occurred, but also keeping an organisation on track, anticipating events before they occur, and responding swiftly to new opportunities that present themselves. Strategic control is also important for monitoring how well the organisation is using its existing resources.

From Figure 8 it can be deduced that, in support of the 4IR transformation strategy, at corporate strategy level the focus should be on strategic surveillance and special alert control. According to [106], strategic surveillance involves monitoring a broad range of events inside and – more often – outside the company that are likely to affect the course of its strategy over time, while special alert control is about management actions undertaken to reconsider thoroughly – and often rapidly – a company's strategy because of a sudden unexpected event.

It should be emphasised that 4IR transformation activities cut through both business unit strategy and functional strategy levels. At the business unit strategy level, the main strategic control used to support a 4IR transformation strategy should be premise control, which, according to [90], is a management process of systematically and continually checking to determine whether the premises upon which the strategy was formulated are still valid.
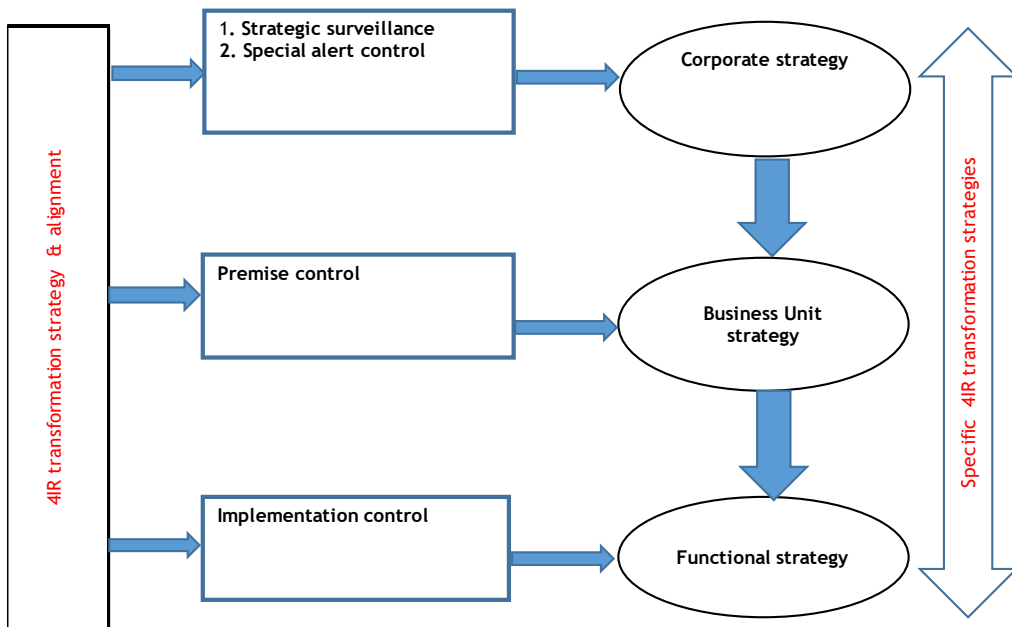
Figure 8: Proposed 4IR strategic controls and their alignment with levels of strategy

At the functional strategy level, an appropriate strategic control would be implementation control, which would be designed to assess whether the overall strategy should be changed in the light of the results associated with the incremental actions that implement the overall strategy [86]. Implementation control involves monitoring strategic thrusts and milestones reviews, and its should use the following steps for post-action control: set standards and performance, measure actual performance, identify deviations from the standard set, and undertake initial corrections and remedial actions.

The last critical step for the 4IR transformation strategy is a clear articulation of the desired outcomes. When a company embraces the 4IR, it might be to attain improved performance (such as the triple bottom line), new forms of value, modified business models, or even smart products. Whatever the desired outcome, it must be clearly articulated, and the assessment of success or failure must be linked to it.

It is worth noting that, just as it is important for the company to integrate its technology strategy [107], [108], [109], it is equally important to integrate the 4IR transformation strategy into the overall corporate strategy.

Considering the complexity, the 'newfangledness', and the agility associated with the 4IR, integrating 4IR technologies into strategic planning involves much more than simply taking technology into account when doing strategic planning.

4.   CONCLUSIONS AND RECOMMENDATIONS

From the above discussion and elaborations, it could be concluded that the advent of 4IR technologies has made the environments in which modern companies operate competitive and increasingly dynamic, thereby rendering the use of conventional methodologies and approaches to technology management and strategy completely inadequate.

Considering the definitions and explanations offered by various authors, it could be concluded that the 4IR is mainly about the intelligent networking of machines and processes for industry, based on cyber-physical systems.

The 4IR phenomenon is a strategic issue for companies in that it requires top management decisions and large amounts of company resources (including money); it affects companies' long-term prosperity; 4IR technological issues are future-oriented; it has multi-business and multifunctional consequences because it affects the whole value chain and stakeholders; and, most importantly, it cannot be implemented without considering the external business environment.

Therefore, for companies to respond to the new opportunities and inherent risks that arise from 4IR technologies, they should systematically manage their 4IR transformation by formulating and implementing 4IR transformation strategies and tactics to augment their conventional corporate, business, and functional strategies. Their 4IR transformation strategy will be not only about the adaptation of 4IR technologies, but also about integrating their current business capabilities with the new capabilities that are made possible by 4IR technologies.

However, owing to the 'newfangledness 'of the 4IR phenomenon, the processes and activities involved in the formulation and implementation of a 4IR transformation strategy are still not sturdy or understood well – hence the need to outline the key principles underlying the formulation and implementation of a 4IR transformation strategy.

The key principles underlying a 4IR transformation strategy are, first, the understanding that companies usually have three tiers or levels of strategy, and that the 4IR cuts through all of them; and second, that a 4IR transformation strategy's main objective is not to replace or dictate the company's corporate strategy: rather, the 4IR transformation strategy should be viewed as one element in an overall competitive strategy, and thus must be reinforced by the actions of both the business unit and the functional unit levels.

The critical steps involved in the formulation and implementation of a 4IR transformation strategy start by identifying and understanding the triggers/inducers for a company to embark on the 4IR transformation journey, followed by understanding and being conversant with the drivers of the 4IR in the context of the external environment (operating, industry, and remote environments). The third critical step involves the application of a technology management framework to link the company's activities to the 4IR transformation strategy.

The fourth step entails the implementation and execution phase of the 4IR transformation strategy, which consists of key aspects such as stakeholder engagement, monitoring plans, evaluating programmes, and integrating capabilities, policies, and procedure developments.

The fifth critical step in the 4IR transformation strategy is strategic control, which is mainly concerned with tracking the strategy as it is being implemented, detecting problems and changes in its underlying premise, and responding accordingly where necessary. The strategic controls are divided into three categories: those managed at the corporate level, those managed at the business level, and those managed at the functional level.

Recommended areas for future research include a scholarly study of the application and implementation of a transformation strategy, and the deployment of technological capabilities and resources in the 4IR age and its relationship to building a sustainable competitive advantage, and understanding how it enhances organisational performance.

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