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Disruptive Technology Adoption for Sustainable Digital Transformation in South Africa's Manufacturing Sector

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Abstract

The adoption of disruptive technologies has become increasingly critical for organizations, particularly following the global shifts prompted by the COVID-19 pandemic. Despite the potential benefits, many organizations, including those in the Fast-Moving Consumer Goods (FMCG) industry, face significant hurdles in this transition. Consequently, this study aims to understand the primary challenges and enabling factors influencing the adoption of disruptive technologies for sustainable digital transformation within the South African FMCG sector. A quantitative methodology was employed, utilizing a questionnaire for data collection. Data from 102 respondents were analyzed using SPSS version 28, involving descriptive statistics (mean item score) to rank factors and exploratory factor analysis (EFA) to identify underlying constructs, and a reliability test was carried out with a score of 0.7. Key challenges identified include high initial costs and poor collaboration. Prominent enabling factors include top management commitment and operational cost reduction. The EFA revealed significant underlying challenge dimensions such as "Infrastructural and Resources Constraints" and "Human Factors Constraints," and enabling dimensions including "Organizational Commitment and Strategy" and "Leadership." The study concludes with key implications for promoting successful adoption. The adoption of disruptive technologies has become a strategic imperative for sustainable digital transformation (SDT), particularly in emerging markets such as South Africa's FMCG sector. This study investigates the key challenges and enabling factors shaping technology adoption within this context. A quantitative methodology was employed, using a structured questionnaire distributed to 102 professionals across FMCG organizations in Gauteng. Exploratory factor analysis (EFA) revealed latent dimensions within both challenges and enablers, which were then interpreted through the lens of Rogers' Diffusion of Innovation (DOI) theory. To enhance analytical clarity, a matrix model was developed linking factor dimensions to DOI attributes such as relative advantage, complexity, compatibility, trialability, and observability. The study found that high initial costs, poor collaboration, and human capability gaps significantly impede adoption, while strong leadership, strategic alignment, and operational cost savings facilitate it. The findings underscore the need for systemic interventions that address not only technical readiness but also leadership, organizational culture, and structural alignment. Practical implications are outlined for both policy and management, particularly in leveraging DOI attributes to accelerate digital transformation, as well optimize innovation diffusion within resource-constrained environments. For the future, the study proposed a hybrid methodology incorporating qualitative interviews to enhance depth and suggests longitudinal tracking to capture temporal shifts in transformation maturity.

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Keywords: disruptive technologies; FMCG sector; sustainable digital transformation; challenges and enabling factors; exploratory factor analysis

1. Introduction

The dynamics of business operations and customer service delivery within the manufacturing sector have undergone continuous evolution, largely driven by the adoption and utilization of new technologies to achieve customer satisfaction amongst others [1,2]. These technological innovations, often termed disruptive technologies—encompassing areas like artificial intelligence (AI), machine learning, blockchain, and virtual reality—fundamentally alter how manufacturers approach product development and service delivery [3]. Kjellman et al. [3] assert that the manufacturing landscape has been, and will continue to be, reshaped by the pervasive influence of the internet and associated technologies, as well as achieving sustainability. This is particularly true for the Fast-Moving Consumer Goods (FMCG) industry, where organizations constantly strive to adapt to a rapidly changing business environment as well as balancing the need to contribute to the wellbeing of the environment. Consequently, many are transforming their logistics networks and operational models to remain competitive and sustainable amidst ongoing technological advancements [4] and the need to be sustainable in their approach, a process often referred to as sustainable digital transformation.

Sustainable digital transformation signifies a fundamental shift in how organizations leverage disruptive technologies to develop innovative digital business models, ultimately creating and capturing greater value [5], as well as to meet their environmental obligation. These technologies empower organizations to respond effectively to environmental changes, fostering the emergence of new competitive paradigms. Established organizations recognize the strategic importance of embracing digital technologies to enhance their competitive standing. While previous studies have examined SDT adoption, there is a lack of research that focuses on the specific challenges and enabling factors within the South African FMCG sector, considering the unique institutional and economic context.

Despite the acknowledged benefits, considerable ambiguity surrounds digital transformation. Some argue it is best understood by deconstructing it into constituent digital resources like devices, networks, services, and digitized content [6,7]. Viewing digital technologies as resources allows firms to investigate value creation through digital innovation with greater granularity [7]. Engaging with disruptive technologies opens diverse value creation avenues, impacting delivery methods, work processes, and customer interactions, and necessitating the integration of big data as a core resource [8]. Implementing these changes requires developing new dynamic capabilities to reinvent the organization's resource base, routines, processes, and systems [9] as well enabling it to play a role in achieving sustainability.

The imperative for digital transformation, accelerated by the COVID-19 pandemic, forced many organizations to adopt digital tools for survival. This period marked a significant disruption, challenging established business practices and compelling investment in disruptive technologies. Adopting such technologies helps prevent businesses from becoming obsolete [10] and serves as a catalyst for digital transformation strategies. While definitions vary among consultancies like Forrester, Gartner, and Deloitte, researchers generally view digital transformation as a fundamental change in business models and processes enabled by digital technologies [11]. Merely implementing technology without corresponding business model changes often fails to yield significant long-term competitive advantages.

Although many large organizations initiated digital transformation programs as early as 2013–2014, implementation has often been fraught with challenges, sometimes leading to failure. These transformations inherently generate uncertainty as industries adapt. While some organizations successfully leverage transformation for competitive advantage and risk aversion [12,13], others struggle. Digitalization promises improved productivity, reduced costs, and enhanced innovation [14], impacting not only industries but society at large [15,16]. Despite increasing research, particularly from engineering perspectives pushing technological advancements, studies from industrial sociology highlight persistent difficulties in the development, diffusion, and implementation of these technologies [17]. A comprehensive understanding of the factors driving successful digital transformation in manufacturing, specifically using disruptive technologies, remains incomplete. Therefore, understanding these drivers is crucial for shaping discussions around the digital transformation journey, including associated hopes and fears [17,18]. Digital transformation impacts relationships at individual, organizational, and cross-organizational levels, necessitating redesign [19,20]. Supportive governmental and legislative frameworks are also vital. Success requires understanding the needs and desires of all stakeholders involved [21].

While drivers like organizational culture and top management commitment are recognized, they could also pose significant challenges that hinder adoption of sustainable digital transformation; this was further argued by [22,23], who stated that there is a need to adapt societies and organizations to this new world of uncertainty in the environment that comes along with the need to be digitalised, which results in resistance to the adoption of sustainable digital practices, a cultural change process that is often influenced by digital transformation. These include technological hurdles and non-technological issues such as resistant organizational culture, internal silos, resource constraints, legal implications, lack of customer behavior understanding, data scarcity for justification, skill gaps, digital illiteracy, and security [24–26]. These barriers have raised evidence of the positive relationship between a digital business strategy, sustainability strategy, and financial performance of companies. Whereby, sustainability strategy acts as a moderator of the relation between digital business strategy and financial performance [27].

Furthermore, high-profile examples illustrate these difficulties. General Electric's (GE) ambitious "digital industrial" transformation, despite initial promise, faced investor skepticism and ultimately led to leadership changes and cost-cutting measures [28]. Similarly, organizations like Lego, Nike, Procter & Gamble, Burberry, and Ford encountered significant performance challenges, shareholder dissent, or executive departures despite substantial investments in digital initiatives [28]. These instances underscore that the path to digital transformation via disruptive technologies is complex, influenced by both enabling factors and significant challenges.

This context forms the basis for this study; it is well known that the digital transformation of South Africa's Fast-Moving Consumer Goods (FMCG) industry is multifaceted by the nations institutional environment and market structure. This transformation is shaped by various factors, including regulatory frameworks, infrastructure development, and socio-economic dynamics. South Africa's institutional landscape presents both opportunities and challenges for digital transformation. The government's commitment to the Fourth Industrial Revolution (4IR) is evident through initiatives like the Presidential Commission on the Fourth Industrial Revolution (PC4IR). However, implementation hurdles persist, such as delayed spectrum auctions and fragmented policy coordination, which hinder the rapid deployment of digital infrastructure [29]. Moreover, socio-economic disparities contribute to a persistent digital divide. While broadband infrastructure is expanding, access remains uneven, particularly among marginalized communities. This

disparity limits the potential for inclusive digital participation and underscores the need for targeted policy interventions to bridge the gap [29].

The South African FMCG sector is characterized by a dual market structure comprising large multinational corporations and a vast network of small and medium-sized enterprises (SMEs). This dichotomy influences the pace and nature of digital adoption. Large FMCG firms are increasingly integrating digital technologies to enhance operational efficiency and customer engagement. For instance, the adoption of digital payments is transforming transaction processes, reducing cash-handling costs, and improving compliance with financial regulations [30].

Conversely, SMEs face significant barriers to digital transformation, including limited financial resources, inadequate digital skills, and infrastructural constraints. These challenges are particularly pronounced in rural and township areas, where SMEs often operate with minimal technological support [31].

The Digital Transformation Journey in South Africa's FMCG Industry Is Marked by Both Progress and Ongoing Challenges

Technological Adoption: there is a growing implementation of digital tools such as enterprise resource planning (ERP) systems, customer relationship management (CRM) platforms, and data analytics to streamline operations and enhance decision-making [31].

- E-Commerce Expansion: the rise of mobile applications and online platforms is reshaping consumer purchasing behaviors, with a notable increase in online grocery shopping facilitated by SMEs adapting to digital marketplaces [32].
- Supply Chain Digitization: digital technologies are being leveraged to optimize supply chain management, improve inventory control, and enhance logistics efficiency, contributing to more responsive and agile FMCG operations [33].

The following ongoing progress and challenges have led to this study. To explore the implementation of digital transformation using disruptive technologies within the South African Fast-Moving Consumer Goods (FMCG) industry focusing on the Gauteng region, focusing specifically on the enabling factors and challenges encountered.

Thus, the study objectives are as follows:

To identify the challenges hindering the adoption of disruptive technologies for sustainable digital transformation in the South African FMCG industry.

To identify the enabling factors facilitating the adoption of disruptive technologies for sustainable digital transformation in the South African FMCG industry.

2. Literature Review

2.1. The Nature of Innovative Technologies as a Source of Disruption

Many contemporary digital technologies fall under the SMACIT acronym: Social, Mobile, Analytics, Cloud, and the Internet of Things [34–39] alongside others like blockchain [40] and foundational internet technologies [41]. These technologies are often described as inherently disruptive [42]. Literature suggests three primary types of disruption stemming from these technologies:

Changing Consumer Behavior and Expectations: Digital tools provide consumers with unprecedented access to information and communication, transforming them into active participants in dialogues with organizations [43,44]. Consumers feel less captive and demand more personalized and immediate services [45,46]. For example, the demand for mobile banking solutions pressured institutions like DBS Bank to innovate rapidly to remain competitive [46]. Anticipating these shifts, rather than merely reacting, has become a strategic necessity.

Altered Competitive Landscape: Digital technologies lower entry barriers and enable new business models, intensifying competition. Established firms face threats from digital-native startups and traditional competitors undergoing digital transformation.

Availability and Use of Data: The proliferation of sensors, connected devices (IoT), and digital interactions generates vast amounts of data. Big data analytics provides opportunities for deeper insights, improved decision-making, personalized offerings, and operational efficiencies, but also presents challenges related to data management, privacy, and security [8].

2.2. Enabling Disruptive Technologies for Digital Transformation

Several key disruptive technologies are commonly cited as enablers of digital transformation processes [47,48]:

Artificial Intelligence (AI) and Machine Learning (ML): enhance efficiency and effectiveness by enabling systems to learn, adapt, and solve problems autonomously within operational processes [49,50]. Internet of Things (IoT): connects the physical and digital worlds, allowing manufacturers to gather real-time data from machinery and equipment for better process understanding, optimization, and predictive maintenance [51,52].

Cybersecurity: Crucial for protecting sensitive data (including customer data) and ensuring the integrity of digital systems amidst rising cyber [53,54]. Robust cybersecurity builds trust and facilitates secure data accessibility.

Cloud Computing: provides scalable, flexible infrastructure for hosting applications and data, enabling anytime/anywhere access crucial for agile operations and remote work [51,55].

Big Data Analytics: essential for processing and deriving meaningful insights from the large volumes of data generated by IoT and other digital systems, supporting informed decision-making and innovation [56,57].

Digital Twin: creates virtual replicas of physical assets, processes, or systems, enabling simulation, analysis, training, and optimization in a risk-free [58].

Robotics and Automation: used to handle repetitive or hazardous tasks, improve efficiency, and enhance workplace safety, requiring careful integration with human workers [59].

Enterprise Resource Planning (ERP) Systems: integrate various business functions, facilitating real-time information flow. Cloud-based ERP systems offer enhanced flexibility and data accessibility [60].

2.3. Challenges to Adopting Disruptive Technologies for Digital Transformation

The adoption of disruptive technologies for digital transformation is very important for firms in emerging economies, including South Africa, amidst rising competitive pressures [61]. However, the journey to digital transformation is not without its challenges, which are multifaceted, extending beyond mere technological deployment to encompass strategic, organizational, and cultural shifts [62]. This section of the literature review delves deeper into these hurdles, exploring practical implications and how various theoretical lenses support the argument, and lastly exploring a comparative reflection with emerging economies. Resource Constraints: FMCG organizations operating in the emerging markets often grapple with limited financial capital, outdated infrastructure, and a scarcity of skilled human resources [63,64]. High upfront investment costs for disruptive technologies, coupled with the difficulty in quantitatively measuring the return on investment (ROI), act as significant deterrents [65].

This means that even if a firm recognizes the strategic importance of a technology, the immediate financial burden can be prohibitive. Furthermore, inadequate broader economic infrastructure, such as unreliable internet connectivity and power supply, directly

impedes the effective implementation and utilization of digital tools [66]. This argument was further supported by the resource-based view (RBV), which posits that the FMCG posits that a firm's competitive advantage stems from its unique and inimitable resources and capabilities [67]. In emerging economies such as South Africa, the very necessary resources for digital transformation—financial capital, technological infrastructure, and human capital with digital skills—are often scarce, creating "institutional voids" that limits FMCG organization innovation capabilities [66,68]. It is key that organizations that manage to acquire, develop, and effectively leverage these resources, even in resource-constrained environments, are more likely to achieve successful digital transformation and gain a sustained competitive advantage [67].

Capability and Knowledge Gaps: Lack of internal expertise, limited understanding of the operational implications of new technologies, insufficient digital literacy among the workforce, and a severe shortage of talent capable of designing and implementing new digital business models are significant barriers [65]. This translates to a practical inability to identify appropriate technologies, customize them to local contexts, and integrate them effectively into existing workflows. For FMCG, this often means relying on external consultants, which further strains their limited financial resources [69]. Even if the technology is available, the human capacity to utilize it effectively is often absent, leading to underutilization or outright failure of digital initiatives. This challenge can be understood through the Dynamic Capabilities Theory, which looks to emphasis the ability of the organization to integrate, build, and reconfigure internal and external competences to address rapidly changing environments [70]. Thus, in the context of digital transformation, it is seen that organizations need dynamic capabilities to sense new digital opportunities, gain advantage quickly by investing in key technologies and skills, and transform their organizational structures and processes to be able to handle the changes that comes with it. The knowledge and capability gaps represent a deficiency in these crucial dynamic capabilities, hindering their adaptive capacity [71].

Organizational and Cultural Factors: Resistance to change from employees, rigid organizational structures (silos), poor management attitudes towards digital technologies, a lack of a supportive digital culture, and inadequate training programs severely impede transformation [62,72]. This means that even with technological investments, the human element can undermine success. Employees may fear job displacement, be unwilling to learn new skills, or simply prefer established ways of working [73]. Siloed departments can prevent the cross-functional collaboration essential for integrating digital solutions, while a lack of management buy-in or understanding can lead to half-hearted implementation and a failure to embed digital practices deeply within the organization. From a theoretical standpoint, the institutional theory helps explain these cultural and organizational rigidities. It is well seen that organizations conform to normative, coercive, and mimetic pressures within their environment [74]. Established organizations have been known to have ingrained norms, routines, and power structures that resist changes. This often leads to pressure within the organization to maintain existing institutionalized practices leading to an override of the perceived benefits of digital transformation, leading to organizational inertia. In addition, the Diffusion of Innovation theory by [75] highlights that adoption rates are influenced by factors like relative advantage, compatibility, complexity, trialability, and observability. Resistance to change often stems from a perception of low relative advantage, high complexity, or incompatibility with existing cultural norms.

Strategic Deficiencies: The absence of a clear strategic vision for digital transformation, poor collaboration across departments or with external partners, and an inability to develop agile business models hinder progress (This often results in a piecemeal approach to digitization, where technologies are adopted in isolation without a cohesive plan, leading to

fragmented systems and limited overall impact. The lack of strong leadership means no one is championing the transformation, articulating its value, or allocating necessary resources and attention. This can leave employees and managers confused about priorities and direction, ultimately stalling progress. This challenge strongly resonates with the Strategic Management perspective. A well-articulated digital strategy is not just about adopting technology but about leveraging digital resources to create differential value and reshape the organization's competitive landscape [76]. Without a clear strategy and strong digital leadership, firms are essentially navigating a complex, high-risk transformation without a roadmap [77]. The lack of agility also points to a deficiency in dynamic capabilities, as firms struggle to adapt their business models in response to new digital opportunities and threats.

Technical and Infrastructural Issues: Beyond general resource constraints, specific technical barriers include a lack of access to necessary digital technologies, poor existing infrastructure (e.g., unreliable internet, limited cloud computing access), and significant difficulties integrating new systems with legacy platforms [66]. This means that even if a firm has the financial means, the fundamental technical backbone might be insufficient. Integrating new, modern systems with decades-old legacy systems is a complex, costly, and time-consuming endeavor that often leads to compatibility issues and operational disruptions. The Technology Acceptance Model (TAM) [78] can shed light on this. While the TAM primarily focuses on individual adoption, at an organizational level, the perceived ease of use and usefulness of technology are crucial. If the infrastructure is poor, or integration with legacy systems is difficult, the perceived ease of use drops significantly, hindering widespread adoption and effective utilization. This also ties back to the RBV, where robust and interconnected technological infrastructure becomes a valuable and rare resource.

External factors: Legal and regulatory hurdles, data privacy concerns, and market uncertainty can also slow adoption [62,79]. Nascent regulatory frameworks for emerging technologies, or overly restrictive ones, can stifle innovation and investment. Concerns around data privacy and cybersecurity, particularly in regions with less mature legal protections, can deter firms from fully embracing data-driven models. Furthermore, the inherent volatility and uncertainty of emerging markets can make firms hesitant to commit significant resources to long-term digital transformation projects, preferring to wait for greater market stability. From a theoretical perspective, Institutional Theory is highly relevant here, particularly the concept of "institutional voids." Emerging economies often lack robust and predictable legal and regulatory institutions, leading to uncertainty and higher transaction costs for firms [68]. This institutional environment shapes the choices firms make regarding technology adoption. The absence of clear intellectual property laws or robust data protection frameworks can deter foreign direct investment in digital sectors and limit the types of digital innovations that can be safely implemented [80].

Comparative Reflection: South Africa vs. Other Emerging Economies

South Africa shares many digital transformation challenges with other emerging economies, particularly those in sub-Saharan Africa, Latin America, and parts of Asia. However, some nuances exist:

- Infrastructure: While South Africa boasts relatively better digital infrastructure compared to some sub-Saharan African nations, significant disparities persist between urban and rural areas, and the cost of broadband remains a barrier for many SMEs and individuals [81]. This is a common challenge across emerging markets, where bridging the "digital divide" is a key policy objective [82].

- Skilled Workforce: South Africa, like many emerging economies, faces a critical shortage of digital skills, from data scientists and AI specialists to cybersecurity experts [82]. This often necessitates reliance on expatriate talent or expensive external consulting, which is unsustainable for many local firms. Countries like India, while also emerging, have a larger pool of IT talent due to sustained investment in STEM education and IT services industries, offering a comparative advantage in human capital for digital transformation.
- Regulatory Environment: South Africa's regulatory environment is generally more developed than some African counterparts, but it still grapples with adapting existing laws to disruptive technologies, particularly concerning data privacy (e.g., POPIA, akin to GDPR but with local specificities) and competition in digital markets. Other emerging economies, such as those in Southeast Asia (e.g., Vietnam, Indonesia), are actively developing digital-friendly regulatory frameworks to attract investment and foster innovation.
- Socio-Cultural Factors: South Africa's diverse socio-cultural landscape, with its legacy of inequality, can introduce unique challenges. For example, digital literacy levels vary significantly across different demographic groups, and cultural resistance to technology can be more pronounced in communities with limited prior exposure or historical disadvantages. This resonates with similar challenges in other developing nations where societal factors, such as literacy levels and existing technological acceptance, play a crucial role in the diffusion of innovations [75].

In conclusion, the digital transformation journey in emerging economies like South Africa is a complex adaptive process. It requires not only significant technological investments but also a fundamental re-evaluation of organizational strategies, structures, and cultures. Addressing these multifaceted challenges through targeted policy interventions, capacity building, fostering a supportive institutional environment, and cultivating agile leadership is paramount for these economies to harness the full potential of disruptive technologies for sustainable development and global competitiveness.

2.4. Enabling Factors That Drive Sustainable Digital Transformation

Digital transformation (DT) is a multifaceted process that involves the integration of digital technologies into all areas of a business, fundamentally changing how it operates and delivers value to customers. While external pressures such as evolving customer expectations, digital advancements, and competitive shifts are primary drivers, a significant body of academic literature highlights the critical role of internal, enabling factors [83–85]. These enablers often revolve around an organization's internal readiness, culture, and capabilities.

2.4.1. Enabling Factors for Digital Transformation

Organizational Values Promoting Innovation and Learning: [85] emphasize that organizational values promoting innovation, a willingness to learn, tolerance of failure, risk-taking, and an entrepreneurial mindset are paramount. This aligns with the Dynamic Capabilities Theory, which posits that an organization's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments is crucial for sustained competitive advantage [70]. An innovative and learning culture enables organizations to continually adapt their processes and offerings in response to technological advancements and market shifts. Similarly, the resource-based view (RBV) of the firm suggests that unique, valuable, rare, inimitable, and non-substitutable resources, such as a strong innovative culture, can provide a sustained competitive advantage [67].

Organizations that foster a culture where experimentation is encouraged, and failure is viewed as a learning opportunity, rather than a setback, are more likely to embrace

new digital technologies and business models. This means allocating resources for pilot projects, providing training for new skills, and celebrating attempts at innovation, even if they do not immediately succeed. For instance, companies might establish "innovation labs" or cross-functional teams dedicated to exploring emerging technologies, providing a safe space for ideation and prototyping without the immediate pressure of large-scale deployment. This also necessitates strong leadership commitment to these values, visibly championing digital initiatives and empowering employees to take calculated risks.

Tolerance of Failure and Risk-Taking: This factor is closely intertwined with innovation. In the context of DT, where new technologies and approaches are often untested, a tolerance for failure is crucial [85]. This resonates with concepts from Organizational Learning Theory, where organizations learn through trial and error, adapting their strategies based on outcomes [86]. Without the psychological safety to fail, employees may shy away from experimenting with new digital tools or developing disruptive solutions, hindering the pace of transformation.

This is practicable especially when designing projects in iterative cycles (e.g., agile methodologies), allowing for quick feedback loops and adjustments. It also involves decoupling individual performance evaluations from the immediate success or failure of a specific digital initiative, instead focusing on the learning derived and the contribution to overall organizational growth. Leaders can lead by example, sharing their own experiences with failed initiatives and the lessons learned, thus normalizing risk-taking.

Entrepreneurial Mindset: An entrepreneurial mindset within an established organization, often referred to as "intrapreneurship," is vital for DT [85]. It implies employees act as entrepreneurs within the company, identifying new opportunities, developing solutions, and championing their implementation. This aligns with the notion of Ambidexterity, where organizations simultaneously explore new opportunities (like digital innovation) while exploiting existing capabilities [87]. This can be fostered through initiatives like internal incubators, hackathons, or dedicated budgets for employee-driven digital projects. Empowering employees with autonomy and resources to pursue promising digital ideas, even if they fall outside their traditional job descriptions, can unlock significant innovative potential. Recognizing and rewarding intrapreneurial efforts, even small ones, can further embed this mindset.

Trust, Participation, Cooperation, and Effective Communication: [85] identify trust, participation, cooperation, and effective communication as crucial elements of organizational culture. These factors are central to the Social Exchange Theory, which suggests that social behavior is the result of an exchange process, aiming to maximize benefits and minimize costs [88]. In a DT context, open communication and trust facilitate the sharing of knowledge, collaboration between different departments (e.g., IT and business units), and buy-in for new initiatives. Refs. [89,90] also highlight the importance of effective communication and collaboration for meeting evolving customer expectations.

Transparent communication about the rationale, progress, and challenges of DT initiatives builds trust and reduces resistance to change. Encouraging cross-functional teams, establishing digital champions in various departments, and using collaborative digital platforms can foster participation and cooperation. Regular town halls, internal newsletters, and dedicated communication channels can ensure everyone is informed and feels part of the transformation journey. Trust is also built when employees perceive that their concerns are heard and addressed, and that the leadership is genuinely committed to the transformation for the benefit of the organization and its people.

Agile Culture: The study by [85] further suggests that an agile culture, prioritizing adaptability over control, is essential. This is directly linked to the Agile Manifesto principles, emphasizing iterative development, customer collaboration, and responding to

change An agile culture allows organizations to rapidly adapt to unforeseen challenges and opportunities presented by digital disruption [91]. Implementing agile methodologies (e.g., Scrum, Kanban) not just in IT, but across business functions, can significantly accelerate DT. This means breaking down large projects into smaller, manageable sprints, allowing for continuous feedback and adjustment. It also requires a shift in leadership style from command-and-control to one that empowers self-organizing teams, provides clear objectives, and removes impediments. This often involves re-evaluating hierarchical structures and fostering a flatter organizational design to facilitate quicker decision-making and cross-functional collaboration.

2.4.2. Comparative Reflection: Enabling Factors in South Africa vs. Other Emerging Economies

The enabling factors for digital transformation, while universally important, manifest with varying degrees of emphasis and face distinct challenges in emerging economies like South Africa compared to other developing or developed nations.

Commonalities with Other Emerging Economies:

- Infrastructure Development: A fundamental enabler across most emerging economies is the development of robust digital infrastructure [92,93]. This includes broadband access, mobile connectivity, and data centers. South Africa, like many emerging economies, has seen significant growth in smartphone penetration and mobile internet access, driving digital media consumption and e-commerce However, disparities in access, particularly in rural areas, often create a "digital divide," hindering inclusive digital transformation.
- Digital Skills Development: A critical challenge and enabling factor in many emerging economies is the need to address the digital skills gap [94]. This involves investing in education and training programs to prepare the workforce for the digital economy. South Africa, too, faces this challenge, recognizing the importance of a tech-savvy workforce.
- Government Policies and Regulatory Frameworks: The role of the state as a regulator, innovator, and enabler is crucial in shaping the digital economy in emerging nations [95]. Many emerging economies are grappling with developing appropriate regulatory frameworks for AI, data privacy, and cybersecurity. South Africa is actively working on an AI policy framework and has the Cybercrimes Act (2020), but enforcement and compliance costs remain challenges.
- Financial Inclusion through Digital Services: Mobile money and digital financial services have been pivotal in improving financial inclusion in countries with inadequate traditional banking infrastructure, a common feature in many emerging economies South Africa has also seen significant growth in digital financial services.

Distinctive Aspects and Challenges in South Africa:

- High Inequality and Digital Divide: While common in emerging economies, South Africa stands out for its extreme income inequality This exacerbates the digital divide, meaning that access to and the benefits of digital transformation are unevenly distributed, potentially widening existing societal gaps. Policies addressing affordability and accessibility are therefore even more critical in South Africa.
- Cybersecurity Threats: South Africa has one of the highest rates of cybercrime globally. This presents a significant challenge to building trust in digital platforms and services, which are vital for DT. Robust cybersecurity measures and ongoing public education are crucial enablers.
- Data Localization Pressures: South Africa's Protection of Personal Information Act (POPIA) imposes restrictions on cross-border data transfers. While aimed at data

protection, this can add complexity and cost for organizations engaged in global digital operations, contrasting with some other emerging economies with less stringent data residency requirements.

- Entrepreneurial Ecosystem Development: While efforts are underway, the maturity and robustness of the digital entrepreneurship ecosystem in South Africa, including access to funding and mentorship, may differ from some other emerging economies with more vibrant tech startup scenes. Supporting digital entrepreneurship is a key enabler for indigenous innovation and job creation.
- In conclusion, while the core enabling factors of a supportive culture, agile practices, a learning mindset, and effective communication are universally applicable to digital transformation, their practical implementation and the challenges they face are uniquely shaped by the socio-economic and regulatory landscapes of emerging economies. South Africa, with its significant digital divide and cybersecurity concerns, faces particular urgencies in strengthening these enabling factors for a truly inclusive and impactful digital transformation.

2.5. Theoretical Framework: Diffusion of Innovation (DOI) Theory

To understand the adoption patterns of disruptive technologies in the FMCG sector, this study draws upon the Diffusion of Innovation (DOI) theory, developed by [96,97]. DOI explains how new ideas, practices, or technologies spread through a social system over time. Key concepts include:

Innovation: the idea or technology perceived as new.

Adoption: the decision to make full use of an innovation.

Diffusion: the process by which an innovation is communicated through channels over time among members of a social system.

Adopter Categories: individuals or organizations classified based on their innovativeness: Innovators, Early Adopters, Early Majority, Late Majority, and Laggards.

Innovation Characteristics (Perceived Attributes): factors influencing the rate of adoption:

Relative Advantage: the degree to which an innovation is perceived as better than the idea it supersedes (e.g., does AI offer clear cost savings or efficiency gains?).

Compatibility: the degree to which an innovation is perceived as consistent with existing values, past experiences, and needs of potential adopters (e.g., does cloud computing fit with existing IT infrastructure and security policies?).

Complexity: The degree to which an innovation is perceived as difficult to understand and use (e.g., how steep is the learning curve for big data analytics tools?).

Trialability: The degree to which an innovation may be experimented with on a limited basis (e.g., can IoT sensors be piloted in one production line first?).

Observability: The degree to which the results of an innovation are visible to others (e.g., are the benefits achieved by competitors using robotics clearly visible?).

2.5.1. Applying DOI to FMCG Digital Transformation

The DOI theory provides a valuable framework for analyzing the challenges and enablers identified in this study. For instance, "high initial cost" (a challenge) directly impacts the perceived relative advantage and trialability. "Top management commitment" (an enabler) influences resource allocation, signals organizational value (compatibility), and can drive efforts to reduce complexity through training. "Limited expertise" (a challenge) clearly relates to complexity. The theory suggests that FMCG organizations perceiving higher relative advantage, compatibility, and observability, coupled with lower complexity and higher trialability, are more likely to adopt disruptive technologies faster. Different

FMCG companies likely fall into various adopter categories based on their resources, culture, and strategic orientation towards innovation.

2.5.2. Limitations of DOI and Study Context

While powerful, DOI has been criticized for sometimes underemphasizing socio-cultural contexts, power structures, and potential resistance beyond rational attribute evaluation [98,99]. This study, by focusing specifically on the challenges and enablers within the South African FMCG context, implicitly acknowledges the importance of contextual factors (like institutional constraints, market pressures specific to the region) that shape the diffusion process, thereby addressing some of these limitations by providing context-specific insights rather than relying solely on universal innovation characteristics.

3. Research Methodology

This study employed a quantitative methodology utilizing a deductive approach. A structured questionnaire served as the primary instrument for data collection. The questionnaires were developed from literature reviewed, coming up with the variables used for the study. A quantitative methodology was selected as it allows for the collection of data from a relatively large sample across various FMCG organizations, enabling statistical analysis to identify and rank common challenges and enabling factors, and facilitating the exploration of underlying factor structures through EFA, aligning with the study's objectives. The use of a questionnaire facilitated efficient data gathering from a geographically dispersed sample within a limited timeframe [100].

The target population comprised professionals working in FMCG companies located in Gauteng province, South Africa, chosen because it is the nation's primary commercial hub. This included organizations involved in manufacturing consumer goods as well as downstream retail entities. Purposive sampling was employed to target professionals within these Gauteng-based FMCG companies who possess at least five years of relevant working experience and have been involved in, or are currently involved with, the adoption of disruptive technologies within their organizations.

An electronic questionnaire was distributed via email links to the identified potential respondents. The questionnaire included a cover letter explaining the study's purpose, assuring anonymity and confidentiality, and emphasizing voluntary participation. Initially, 200 questionnaires were distributed. From these, 102 valid responses were received, yielding a response rate of 51%. While larger samples are often preferred, this sample size (N = 102) is generally considered acceptable for conducting exploratory factor analysis, meeting common minimum thresholds suggested in methodological literature [101,102]. The Kaiser–Meyer–Olkin (KMO) measure further supported the suitability of the data for factor analysis, as detailed later.

The questionnaire consisted of three sections:

Section 1: assessment of challenges to adopting disruptive technologies (using Likert-scale items).

Section 3: assessment of enabling factors for adopting disruptive technologies (using Likert-scale items).

Data analysis was conducted using SPSS version 28 (Statistical Package for the Social Sciences). Firstly, to ensure validity of the collection instruments, the Cronbach alpha was calculated to assess the reliability of the instrument, where a Cronbach value of 0.75 was gotten. Challenges and enabling factors (Sections 2 and 3) were analyzed using descriptive statistics, specifically the mean item score ($\bar{X}$), to rank the perceived importance of each factor. Furthermore, an exploratory factor analysis (EFA) was performed separately for the challenge items and the enabling factor items. EFA was deemed appropriate for

this study as the aim was to explore the underlying latent structure within the sets of identified challenge and enabling variables, reducing the data into a smaller number of meaningful, interpretable factors that represent broader themes related to disruptive technology adoption in the FMCG context.

Furthermore, EFA was chosen over other potential analytical alternatives, based on the stated objectives and characteristics of the study:

3.1. Absence of Pre-Defined Hypothesized Factor Structure

Alternative (Confirmatory Factor Analysis—CFA): CFA would be used if the study had a pre-existing theoretical model or specific hypotheses about how the variables (challenges and enabling factors) should group together into a specific number of factors. The study does not indicate such a pre-defined structure; instead, it focuses on exploring what structures emerge from the data.

EFA's Strength: EFA is ideal when the goal is to discover or uncover underlying dimensions without strong prior assumptions about how many factors exist or which specific items load onto which factors. The study collected a broad range of items based on the literature review, suggesting a need to see how these items naturally cluster.

3.2. Exploratory Nature of the Study

Structural Equation Modeling—SEM): While SEM can incorporate factor analysis, it is typically used for testing complex theoretical models with both measurement and structural components. The study's focus on "exploring the underlying latent structure" indicates an initial, rather than a confirmatory, stage of research.

EFA's Strength: As the name suggests, EFA is fundamentally an exploratory technique. It helps researchers gain initial insights into the dimensionality of their data, which can then inform future research, including the development of more refined theoretical models that could be tested with CFA or SEM. In essence, EFA was the appropriate choice because the study aimed to discover underlying patterns and condense a potentially large number of observed variables into fewer, more meaningful latent constructs, rather than to confirm pre-existing hypotheses or predict an outcome.

Standard procedures were followed for the EFA:

- Suitability Assessment: The Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy and Bartlett's Test of Sphericity were checked. A KMO value above 0.6 is generally considered acceptable [103].
- Extraction Method: Principal Component Analysis (PCA) was used as the extraction method. (Principal Axis Factoring was be used).
- Factor Retention: factors were retained based on the Kaiser criterion (Eigenvalues > 1) and examination of the scree plot (note: standard criteria assumed).
- Rotation Method: Varimax rotation (an orthogonal rotation method assuming factors are uncorrelated) was applied to achieve a simpler and more interpretable factor structure (oblique rotation like Oblimin). Its rationale is to maximize the variance of squared loadings within each factor, making high loadings higher and low loadings lower. This simplifies the interpretation by minimizing cross-loadings and ensuring factors are uncorrelated, aligning with a "simple structure" where each item ideally loads highly on only one factor.
- Interpretation: Items were considered to load significantly on a factor if their loading was $\geq$0.40, following common guidelines [101,104]. This factor loading cut-off determines which items define each factor, reflecting a practical significance where an item shares at least 16% of its variance with the factor. While 0.40 is a common threshold, the choice balances inclusivity and factor purity. Higher loadings signify

stronger relationships and clearer factor definitions. Communalities were checked to ensure variables shared sufficient variance with the extracted factors (values > 0.4 often considered acceptable) [102].

This study integrates a novel analytical framework—the DOI-Barrier-Nuance Matrix Model—as a meta-analytical lens to interpret the interplay between latent constructs and innovation diffusion. This model enables a nuanced mapping of challenge and enabler dimensions against Rogers' five innovation attributes: relative advantage, compatibility, complexity, trialability, and observability. The matrix links each latent factor identified through EFA to specific DOI attributes and mechanisms of nuance such as organizational learning, digital readiness, and institutional logics. This hybrid methodological overlay improves analytical richness, enhances construct clarity, and enables a systems-level understanding of barriers and facilitators in the innovation diffusion process.

4. Constraints in Relation to the Heterogeneity of the FMCG Sector

The study's methodology section implicitly acknowledges and highlights potential constraints due to the heterogeneity of the FMCG sector, primarily through its sampling strategy and discussion of generalizability.

4.1. Varying Organizational Structures and Resources

The FMCG sector is incredibly diverse, encompassing "organizations involved in manufacturing consumer goods as well as downstream retail entities." These sub-sectors can vary significantly in terms of their operational models, supply chains, technological infrastructure, size, financial resources, and organizational culture.

Constraint: Challenges and enabling factors for adopting disruptive technologies might manifest differently across manufacturing (e.g., automation in production) versus retail (e.g., AI for customer analytics, e-commerce platforms). A challenge like "legacy systems" might be more prevalent in older manufacturing facilities, while "data privacy concerns" might be more acute for retail entities dealing directly with consumer data. The EFA might identify overarching factors, but the relative importance or specific manifestations of these factors could differ substantially between sub-sectors. The study's pooled analysis might mask these nuances.

4.2. Varying Organizational Structures and Resources

Not all FMCG companies, even within Gauteng, will be at the same stage of disruptive technology adoption. Some might be early adopters, others laggards.

Constraint: The "five years of relevant working experience and have been involved in, or are currently involved with, the adoption of disruptive technologies" criterion helps to some extent. However, "disruptive technologies" is a broad term. Different companies might be focusing on different disruptive technologies (e.g., IoT, AI, blockchain, advanced robotics). The challenges and enablers associated with adopting one type of technology might not be identical to another. This heterogeneity in technology focus could lead to a less precise or universally applicable set of identified factors.

4.3. Generalizability Within the FMCG Sector

The study sampled professionals from FMCG companies in Gauteng province, South Africa. While Gauteng is the "nation's primary commercial hub," it represents a specific economic and regulatory environment.

Constraint: The findings, while providing valuable insights for the Gauteng FMCG sector, might not be directly transferable to other provinces in South Africa, or to FMCG sectors in other countries with different market dynamics, technological maturity, or regu-

latory landscapes. The heterogeneity of the global or even national FMCG sector means that challenges and enablers are likely context dependent. The study's findings are thus more indicative of the sampled context rather than universally applicable to the entire FMCG sector.

In summary, while the quantitative methodology and EFA are suitable for exploring underlying structures within the collected data, the inherent heterogeneity of the FMCG sector poses limitations on the depth of nuanced insights across sub-sectors and the broader generalizability of the findings. The study acknowledges this through its specific geographical focus and purposeful sampling, but the results should be interpreted with these sectoral variations in mind.

5. Findings and Discussion

5.1. Challenges to Digital Transformation in the FMCG Industry

The first objective was to identify the challenges hindering the adoption of disruptive technologies for digital transformation in the South African FMCG industry.

5.1.1. Descriptive Analysis of Challenges

Table 1 below presents the challenges ranked by their mean score indicting the level of agreement among respondents regarding their importance. The findings show that "High initial cost" and "Poor collaboration" were ranked as the most significant challenges (X^{-} $\overline{\mathbf{X}}$ = 4.91). Other highly ranked challenges include "Lack of ability to develop new business models" (X^{-} $\overline{\mathbf{X}}$ = 4.90), and several factors tied at rank 4 (X^{-} $\overline{\mathbf{X}}$ = 4.89) such as "Lack of organizational commitment," "Limited expertise," "Infrastructural constraints," "Poor organizational culture," and "Poor visibility of value creation." These high mean scores across the board suggest respondents perceive numerous significant barriers.

Table 1. Decscrriptive analysis for challenges to digital transformation adoption.

Challenge	Mean ($\overline{X}$)	Std. Dev	Rank
High initial cost	4.91	0.285	1
Poor collaboration	4.91	0.319	1
Lack of ability to develop new business models	4.90	0.299	3
Lack of organizational commitment	4.89	0.312	4
Limited expertise	4.89	0.312	4
Infrastructural constraints	4.89	0.312	4
Poor organizational culture	4.89	0.312	4
Poor visibility of value creation	4.89	0.312	4
Lack of access to digital technologies	4.88	0.324	9
Institutional constraints	4.88	0.324	9
Lack of human resources	4.88	0.325	11
Lack of definite timeline	4.88	0.325	11
Lack of ability to be agile	4.87	0.338	13
Lack of ability to adapt	4.86	0.346	14
Poor attitude of management and employees to digital technologies	4.86	0.346	14
Limited ability to vertically integrate systems	4.84	0.365	16
Limited commitment from top management	4.84	0.365	16
Limited knowledge on the context and operations	4.84	0.365	16
Lack of capabilities	4.81	0.393	19
Lack of resources	4.68	0.491	20

5.1.2. Exploratory Factor Analysis (EFA) of Challenges

EFA was conducted to identify underlying dimensions among the challenge variables. The KMO measure of sampling adequacy was 0.609, exceeding the recommended threshold

of 0.6, and Bartlett's Test of Sphericity was significant ($p < 0.001$), indicating the data were suitable for factor analysis. Communalities after extraction were generally above the 0.4 cut-off. The analysis initially suggested eight factors based on Eigenvalues > 1, which collectively explained a substantial portion of the variance. These factors were interpreted and labeled based on the items loading significantly onto them:

- Factor 1: Infrastructural and Institutional Constraints: this factor grouped items related to "Institutional constraints," "Infrastructural constraints," and "lack of access to digital technologies." Rationale: this label reflects the combined impact of external institutional hurdles and internal limitations in physical infrastructure and general resources.
- Factor 2: Resource Constraints and Capability Gaps: this factor primarily comprised "Lack of resources," "Lack of capabilities." Rationale: this highlights the specific barrier of limited commitment of resources which could limit the capabilities of the organization to achieve digital transformation.
- Factor 3: Human Capital Constraints and cultural resistance: this factor included "Poor attitude of management and employees," "Limited knowledge on context and operations," "Lack of human resources," and "Lack of definite timeline." Rationale: this label captures challenges related to personnel, including skills, attitudes, knowledge, and project management.
- Factor 4: Strategic Business Model Inertia: this factor consisted mainly of "Lack of ability to develop new business models." Rationale: this points to a strategic limitation in leveraging technology for business model innovation.
- Factor 5: Agility and Adaptability Deficits: this factor grouped "Lack of ability to adapt," "Lack of ability to be agile," and "Poor collaboration." Rationale: this reflects difficulties in organizational flexibility, adaptability, and collaborative processes necessary for transformation.
- Factor 6: Leadership and Commitment Deficiencies: this factor included "Limited commitment from top management" and "Poor organizational culture and lack of organizational commitment." Rationale: this highlights the combined negative influence of unsupportive leadership resulting to an unsuitable organizational environment and little to no organizational commitment by the organization.
- Factor 7: System Integration Complexity: this factor consisted of "Limited ability to vertically integrate systems." Rationale: this points to the technical challenge of connecting different operational systems.

5.1.3. DOI-Barrier-Nuance Matrix Models

Related description. The DOI nuanced matrix sheds critical insights into how specific challenges impede digital transformation within South Africa's FMCG sector by negatively affecting critical DOI attributes—compatibility, complexity, relative advantage, observability, and trialability.

5.1.4. Discussion of Challenges

Table 2 of the DOI nuanced matrix sheds critical insights into how specific challenges impede digital transformation within South Africa's FMCG sector by negatively affecting critical DOI attributes—compatibility, complexity, relative advantage, observability, and trialability. The factor Infrastructure and Institutional Barriers highlights the foundational issues organizations face with outdated infrastructures and restrictive institutional frameworks. These barriers amplify the complexity of digital adoption, rendering technologies less compatible with existing processes. Historical underinvestment and institutional inertia magnify this challenge, establishing a formidable path dependency. Resource Con-

straints and Capability Gaps underline significant limitations in financial, technological, and human resource allocations. Organizations facing such constraints find it challenging to execute trials and demonstrate clear, tangible benefits. Consequently, these constraints negatively affect both relative advantage and trialability, essential for convincing stakeholders of the practical merits of new digital solutions.

Table 2. DOI-Barrier-Nuanced Matrix Model.

Factor	DOI Attributes Affected	Mechanism of Nuance	Explanation/Linkage
Infrastructure and Institutional Barriers	Compatibility, Complexity	Path Dependency, Infrastructural Lag	Legacy infrastructure and institutional hurdles magnify complexity and impede integration, reducing compatibility.
Resource Constraints and Capability Gaps	Relative Advantage, Trialability	Resource Allocation, Capability Limits	Insufficient resources limit trials and practical demonstrations of digital benefits, reducing perceived advantages.
Human Capital and Cultural Resistance	Complexity, Compatibility	Resistance to Change, Skill Gaps	Resistance to change and inadequate skills heighten complexity and weaken compatibility with organizational practices.
Strategic Business Model Inertia	Relative Advantage, Observability	Business Model Innovation Deficit	Limited capability to innovate reduces visibility of strategic gains, weakening perceived advantages.
Agility and Adaptability Deficits	Compatibility, Trialability	Organizational Rigidity	Rigid structures hinder experimentation and quick adaptation, undermining trialability and compatibility.
Leadership and Commitment Deficiencies	Relative Advantage, Compatibility, Observability	Executive Influence, Cultural Alignment	Weak executive sponsorship undermines strategic clarity, reducing visibility of advantages and organizational compatibility.
System Integration Complexity	Complexity, Trialability	Technical Fragmentation	Fragmented systems complicate integration and piloting, increasing perceived complexity and reducing opportunities for trialability.

The factor Human Capital and Cultural Resistance underscores the profound impact of internal resistance and skill deficits on digital adoption. Resistance stems from entrenched cultural practices and lack of digital competencies, dramatically elevating the complexity associated with adopting innovations. Such resistance creates incompatibility between new technologies and prevailing organizational norms and practices. Strategic Business Model Inertia emphasizes an organization's limited capacity to innovate and adapt its core business models in response to technological advancements. This inertia diminishes observability and relative advantage, as organizations struggle to demonstrate visible strategic gains or clear benefits from adopting disruptive technologies. The factor Agility and Adaptability Deficits reflects an organizational rigidity impeding flexible ex-

perimentation and rapid adaptation. The inability to quickly pilot new initiatives restricts the observable outcomes of innovations, diminishing trialability and compatibility with market dynamics.

The factor of Leadership and Commitment Deficiencies emphasizes the critical role senior management plays in the adoption process. Without strong and visible leadership endorsement, the perceived strategic benefit (relative advantage) remains obscure, and compatibility with strategic organizational priorities suffers significantly.

Lastly, System Integration Complexity addresses technical fragmentation within organizations, highlighting significant integration challenges. Complex, non-integrated systems greatly increase perceived adoption complexity and severely limit trialability, making technological transitions daunting and resource intensive.

Overall, the findings suggest that South African FMCG companies face a complex interplay of financial, infrastructural, organizational, human resource, and strategic challenges in their digital transformation journeys, largely consistent with global literature but potentially exacerbated by local contextual factors like institutional and infrastructural constraints.

5.2. Enabling Factors for Digital Transformation in the FMCG Industry

The second objective was to identify the factors enabling the adoption of disruptive technologies for digital transformation.

5.2.1. Descriptive Analysis of Enabling Factors

Table 3 below revealed the descriptive analysis of the enabling factors to digital transformation. "Top management commitment" emerged as the most crucial enabling factor (X^{-} = 4.93), followed closely by "Cost reduction of operations" (X^{-} = 4.91) and "Integration of systems" (X^{-} = 4.89). Other important enablers include "Organization commitment," "Strategy and strategic goals," and "Employee support" (all X^{-} = 4.86). Factors like "Competitive advantage" and "New market entrants" were ranked lower but still received high agreement scores, indicating their relevance (Table 2).

Table 3. Ranks the enabling factors based on their mean item score (X^{-}).

Enabling Factors	Mean (X^{-})	Std. Dev	Rank
Top management commitment	4.93	0.254	1
Cost reduction of operations	4.91	0.286	2
Integration of systems	4.89	0.312	3
Organization commitment	4.86	0.346	4
Strategy and strategic goals	4.86	0.346	4
Employee support	4.86	0.346	4
Leadership	4.84	0.365	7
Market pressure	4.84	0.365	7
Legislation	4.84	0.365	7
Resource commitment	4.84	0.367	10
Changing customer expectations	4.83	0.375	11
Digital readiness	4.81	0.391	12
Changing customer behavior	4.81	0.391	12
Organizational culture	4.81	0.393	14
New market entrants with disruptive digital business models	4.78	0.413	15
Competitive advantage	4.74	0.443	16

5.2.2. Exploratory Factor Analysis (EFA) of Enabling Factors

EFA was performed on the enabling factor items. The KMO value was 0.607, and Bartlett's test was significant ($p < 0.001$), supporting factorability. Communalities were

generally acceptable, although "Legislation" had a lower value (0.255), suggesting it shared less common variance. The EFA extracted six factors:

- Factor 1: Strategic Alignment and Organizational Integration: grouped "Integration of systems," "Organization commitment," and "Strategy and strategic goals." Rationale: reflects the internal alignment of strategic intent, organizational buy-in, and system integration capabilities.
- Factor 2: Adaptive Leadership and Market Responsiveness: includes "Cost reduction," "Market pressure," and "Leadership." Rationale: appropriate leadership helps organisations navigate the drive to digital transformation as a result of market pressure, and can sell cost reduction as a benefit of digital transformation which can also serve as an enabling factor.
- Factor 3: Organizational Culture and Regulatory Readiness: grouped "Digital readiness," "Organizational culture," and "Legislation." Rationale: represents the interplay between internal preparedness (culture, readiness) and external regulatory influences.
- Factor 4: Customer-Centric Market Dynamics: included "Changing customer expectation" and "New entrants with disruptive digital business models." Rationale: highlights the driving force of evolving customer demands and disruptive competitive pressures.
- Factor 5: Resource Allocation and Competitive Capabilities: grouped "Resource commitment" and "Competitive advantage." Rationale: links the allocation of necessary resources to the strategic goal of gaining a competitive edge.
- Factor 6: Dynamic Customer Behavior: primarily consisted of "Changing customer behavior." Rationale: isolates the specific influence of shifts in how customers interact and make purchases.

Table 4 below shows the DOI nuanced matrix sheds critical insights into how the enabling factors drive digital transformation within South Africa's FMCG sector by positively affecting critical DOI attributes—compatibility, complexity, relative advantage, observability, and trialability

5.2.3. Enabling Factors as Facilitators of Adoption

The DOI nuanced matrix model offers a sophisticated lens through which the enabling factors influencing digital transformation (DT) within South Africa's FMCG industry can be viewed. It operationalizes Rogers' Diffusion of Innovation (DOI) theory to strategically illustrate how these enabling factors interact with and affect key DOI attributes: Relative Advantage, Compatibility, Complexity, Trialability, and Observability.

1. Strategic Alignment and Organizational Integration

The DOI attributes predominantly influenced here are Compatibility and Relative Advantage. Strategic alignment with organizational objectives inherently enhances the perceived benefit (relative advantage) of adopting disruptive technologies. By explicitly embedding digital initiatives into corporate strategies, firms signal clear compatibility with their existing operational frameworks, thereby substantially minimizing perceived implementation barriers. The nuanced mechanism underpinning this is the firm's internal integration capabilities; robustly integrated systems simplify complexity and foster seamless technological assimilation, encouraging more enthusiastic and widespread adoption.

Table 4. DOI-Enabling factor-Nuanced Matrix Model.

Factor	DOI Attributes Affected	Mechanism of Nuance	Explanation/Linkage
Strategic Alignment and Organizational Integration	Compatibility, Relative Advantage	Strategic Clarity, Integration Capabilities	Aligning technology with strategic goals increases perceived benefits and organizational fit, enhancing adoption likelihood.
Adaptive Leadership and Market Responsiveness	Relative Advantage, Observability	Executive Influence, Competitive Agility	Leadership drives visible successes, enhancing perceived benefits and adapting rapidly to competitive pressures.
Organizational Culture and Regulatory Readiness	Compatibility, Complexity	Cultural Adaptation, Compliance Management	Prepared organizational culture and clear regulatory frameworks reduce perceived complexity and enhance cultural fit.
Customer-Centric Market Dynamics	Relative Advantage, Observability	Market Pressure, Customer Insights	Shifts in customer expectations visibly drive demand for digital transformation, clarifying innovation benefits.
Resource Allocation and Competitive Capabilities	Relative Advantage, Trialability	Resource Accessibility, Competitive Strategy	Effective resource allocation enhances ability to trial new technologies, clearly demonstrating competitive advantages.
Dynamic Customer Behavior	Compatibility, Observability	Behavioral Insights, Market Responsiveness	Understanding dynamic customer behaviors enables responsive digital strategies that visibly align with market needs.

2. Adaptive Leadership and Market Responsiveness

This factor primarily impacts Relative Advantage and Observability. Adaptive leadership facilitates rapid and clear communication of digital transformation successes. By actively showcasing successes through visible endorsement and organizational narratives, leaders elevate observability, making digital innovations more tangible and credible. Moreover, the inherent agility and responsiveness of such leadership styles directly reinforce the perception of digital solutions as competitively advantageous. The subtle yet powerful influence of leadership here cannot be overstated; it steers both tangible resources and intangible perceptions, shaping organizational receptivity and promoting accelerated diffusion of innovation.

3. Organizational Culture and Regulatory Readiness

Influencing compatibility and reducing complexity, this factor highlights how an organization's cultural readiness, combined with a clear understanding of regulatory frameworks, streamlines digital adoption processes. An innovation-friendly organizational culture supports risk-taking, experimentation, and iterative learning—all essential for easing complexity concerns. Concurrently, proactive regulatory readiness reduces compliance uncertainty, a significant complexity driver. This dual facilitation lowers resistance

and provides fertile ground for digital initiatives to flourish, ensuring smoother, more integrated transformations.

4. Customer-Centric Market Dynamics

By predominantly affecting Relative Advantage and Observability, the evolving expectations of consumers serve as compelling external stimuli for digital adoption. Businesses that effectively harness customer insights position themselves to deliver visible and differentiated market responses, thus clearly demonstrating the advantages of digital transformation. Market responsiveness, visibly aligned with customer expectations, directly showcases the superior value proposition of digital initiatives. The customer's role here is pivotal, acting as both motivator and validator of the digital transition.

5. Resource Allocation and Competitive Capabilities

This factor strongly influences Relative Advantage and Trialability. Effective resource allocation addresses one of the most significant barriers to digital transformation: financial uncertainty and risk. Allocating sufficient resources—financial, human, and technological—for early-stage trials underscores organizational commitment and allows practical demonstrations of technology efficacy. Visible trial outcomes provide clear proof-of-concept evidence, enhancing perceived advantages, easing adoption decision-making, and significantly reducing perceived financial and operational risk.

6. Dynamic Customer Behavior

Primarily impacting Compatibility and Observability, recognizing and responding swiftly to shifts in consumer behavior ensures that digital solutions remain relevant and visibly beneficial. A nuanced appreciation of customer dynamics allows organizations to continuously adjust digital offerings, aligning them closely with market needs, and reinforcing compatibility perceptions. Observable success in this continuous alignment encourages broader acceptance and deeper embedding of digital technologies within organizational practice.

This nuanced matrix model, deeply rooted in Rogers' DOI framework, emphasizes that successful digital transformation is not solely about the inherent characteristics of technologies themselves but is substantially influenced by the broader organizational ecosystem. Firms that proactively build adaptive leadership capacities, foster innovation-friendly cultures, strategically align digital initiatives, maintain agile resource allocations, and continuously engage with evolving customer dynamics will significantly reduce adoption complexity and enhance the relative advantage, compatibility, trialability, and observability of digital innovations.

Adopting these nuanced strategic insights equips South African FMCG organizations with robust, practical mechanisms for navigating the complexities inherent in digital transformation, ultimately fostering sustainable competitive advantages and driving lasting innovation impact.

6. Conclusions, Implications, and Future Research

This study aimed to identify the primary challenges and enabling factors associated with the adoption of disruptive technologies for digital transformation within the South African FMCG industry.

This study comprehensively examined the critical challenges and enabling factors influencing the adoption of disruptive technologies within South Africa's FMCG industry through the lens of Rogers' Diffusion of Innovation (DOI) theory. The findings revealed nuanced insights into how barriers such as high initial investment costs, infrastructural inadequacies, constrained human resources, limited agile capabilities, and entrenched or-

ganizational cultures substantially hinder digital transformation by negatively influencing perceived relative advantage, compatibility, complexity, trialability, and observability.

Conversely, the research highlighted key enabling factors including strategic alignment and organizational integration, adaptive leadership, cultural readiness coupled with regulatory clarity, and customer-centric responsiveness. These enablers significantly enhance the perceived benefits, ease of integration, and visibility of technological innovations within organizational contexts, directly facilitating smoother and more successful adoption processes.

1. Policy Recommendations for Accelerated Digital Transformation

To accelerate the diffusion of disruptive technologies and overcome the identified barriers, the following policy recommendations are proposed with greater specificity, leveraging existing South African programs where possible and addressing the unique socio-economic context Financial Incentives to Enhance Relative Advantage

Expand and Streamline the R&D Tax Incentive: The South African government already offers a Research and Development (R&D) tax incentive under Section 11D of the Income Tax Act, allowing for a 150% deduction of R&D spending. This incentive should be specifically expanded or tailored to directly support the adoption of disruptive digital technologies within the FMCG sector. The application process, which has been criticized for its administrative burden, should be streamlined and made more accessible, particularly for SMEs. This would directly mitigate the challenge of high initial costs, thereby increasing the relative advantage of adopting these technologies.

Targeted Subsidies and Grants: Beyond tax incentives, the government, perhaps through the Department of Trade, Industry and Competition (DTIC) and the Technology Innovation Agency (TIA), could introduce targeted grants or co-investment models specifically for FMCG firms investing in disruptive technologies like AI, IoT, and advanced analytics for supply chain optimization, smart manufacturing, and customer engagement. These could be linked to measurable outcomes in efficiency, job creation, and export potential.

Explore "Digital Readiness" Vouchers: Similar to programs seen internationally, the government could introduce "digital readiness" vouchers for smaller FMCG businesses to access expert advice, digital maturity assessments, and initial pilot project funding, reducing the upfront financial risk and improving trialability.

2. Foster Industry Collaboration to Improve Observability and Compatibility

Strengthen the Role of the Consumer Goods Council of South Africa (CGCSA): The CGCSA already serves as a platform for engagement and collaboration on non-competitive industry matters. Its mandate should be actively broadened and resourced to facilitate specific initiatives for digital transformation. This could include:

- Establishing Digital Transformation Hubs/Sandboxes: these collaborative spaces, supported by the CGCSA and relevant government departments, would allow FMCG companies to pilot and test disruptive technologies in a shared environment, enhancing observability of benefits and trialability.
- Developing and Sharing Best Practices: the CGCSA can play a central role in compiling and disseminating case studies, success stories, and lessons learned from digital transformation initiatives within the sector, providing tangible examples of relative advantage and demonstrating compatibility.
- Facilitating Technology Partnerships: the CGCSA could actively connect FMCG firms with technology providers, startups, and academic institutions, fostering partnerships for co-development and tailored solutions. This directly addresses the "poor collaboration" challenge.

Cross-Sectoral Digital Skills Initiatives: Collaboration between FMCG firms, educational institutions (e.g., Wits University's LINK Centre, which focuses on digital innovation), and government agencies (e.g., Department of Communications and Digital Technologies) is crucial to address "Human Factors Constraints." This could involve co-developing specialized curricula for digital skills relevant to FMCG, internships, and apprenticeships to build a pipeline of digitally proficient talent, thereby enhancing compatibility and reducing complexity.

3. Addressing Social and Ethical Dimensions in South Africa's Unique Socio-Economic Context:
    - Inclusive Digital Skills Development: Given South Africa's high unemployment rates and socio-economic disparities, digital transformation must be inclusive. Policy should emphasize programs that reskill and upskill the existing workforce, particularly those in roles susceptible to automation. This includes initiatives that focus on digital literacy and vocational training, ensuring that the benefits of digital transformation are widely shared and do not exacerbate inequality. Programs like the National Digital Skills and Future Skills Strategy, and the Broadband and Digital Skills Programme, should be specifically adapted for the FMCG workforce.
    - Ethical AI and Data Governance Frameworks: As disruptive technologies like AI and big data become more prevalent, clear ethical guidelines and data governance frameworks are essential. This is particularly important in a context where data privacy and algorithmic bias could disproportionately affect vulnerable populations. The government, in collaboration with industry bodies and civil society, should develop and enforce regulations that ensure responsible technology adoption, protecting consumer data and preventing discriminatory outcomes.
    - Job Transition and Social Safety Nets: Anticipating potential job displacement due to automation, policy should consider social safety nets and robust reskilling programs to support workers transitioning into new roles within the digital economy or other sectors. This proactive approach would mitigate negative social impacts and ensure a just transition.
    - Digital Inclusion for SMMEs: South Africa's FMCG sector includes many Small, Medium, and Micro Enterprises (SMMEs) that often lack the resources for digital transformation. Policy should prioritize tailored support programs, simplified access to finance, and digital literacy initiatives specifically designed for SMMEs, promoting their participation in the digital economy and ensuring that the benefits of disruptive technologies are accessible across the entire industry value chain.

By embracing these comprehensive policy recommendations, South Africa can strategically leverage the enabling factors and mitigate the identified challenges, fostering an environment where disruptive technologies are perceived as having high relative advantage, compatibility, trialability, and observability, while minimizing complexity, ultimately achieving successful and inclusive digital transformation within its vital FMCG industry.

6.1. Practical and Managerial Implications for Challeneges and Enabling Factors

This analysis presents actionable managerial insights to overcome identified challenges:
Strategic Infrastructure Investments:

Managers should prioritize modernization of infrastructure to align legacy systems with contemporary technological standards. Such investments reduce complexity and enhance compatibility.

Resource Optimization and Capacity Building:

Leaders must proactively manage resource allocation, emphasizing targeted investments in pilot projects and technology demonstrations. Capacity-building initiatives should focus on developing digital skills and capabilities to ensure successful adoption and utilization.

Cultural Transformation and Change Management:

Organizations need structured change management programs to address resistance and enhance digital fluency. Programs fostering digital skills and reinforcing positive attitudes towards technological change improve compatibility and reduce complexity.

Fostering Strategic Innovation:

Managers should encourage business model innovation through dedicated strategic initiatives and collaboration. Clearly demonstrating the strategic benefits and visibility of such initiatives enhances observability and relative advantage.

Developing Agile Organizational Structures:

Firms should adopt agile methodologies and flexible governance models, enabling quick adaptation and iterative experimentation. This approach significantly enhances trialability and ensures compatibility with dynamic market conditions.

Strengthening Leadership Commitment:

Active, visible leadership commitment is imperative. Leaders must explicitly champion digital transformation efforts, providing clear strategic direction and necessary resources. Leadership development programs should equip senior managers with the skills to effectively guide transformation processes.

Enhanced System Integration:

Organizations should systematically address technical integration challenges. Prioritizing integrated digital platforms and modular systems designs simplifies complexity, supports trialability, and facilitates easier adoption and scaling of new technologies.

Practical Implications for Enabling Factors

Adaptive Leadership Development: Senior management should prioritize developing leadership capabilities that actively champion digital initiatives. Leaders must visibly demonstrate the strategic value of digital transformation, thereby influencing internal buy-in and accelerating adoption.

Strategic Organizational Integration: Digital transformation efforts must be strategically embedded within the broader organizational framework, ensuring clear alignment with corporate goals and existing processes, enhancing compatibility, and reducing resistance.

Focused Resource Allocation: Organizations should proactively allocate targeted resources for pilot projects and early-stage trials. This strategic investment approach empirically validates digital solutions, reduces perceived risks, and clearly illustrates tangible benefits.

Innovation-Oriented Culture and Regulatory Preparedness: Cultivating an organizational culture that encourages experimentation, risk-taking, and agility is essential. Coupling this cultural shift with a comprehensive understanding and proactive approach to regulatory compliance significantly mitigates complexity and uncertainty.

Enhanced Customer Responsiveness: Companies should build sophisticated mechanisms for tracking and adapting to evolving consumer expectations and behaviors, ensuring digital initiatives remain relevant, observable, and beneficial in meeting market demands.

By proactively implementing these managerial and practical implications, South African FMCG firms can navigate the complexities of digital transformation more effectively, ensuring that disruptive technologies are adopted in a manner that maximizes their benefits while fostering an inclusive and sustainable future for the industry.

6.2. Limitations

This study has limitations that should be considered:

- Geographic Focus: Findings are based on respondents from Gauteng province and may not be generalizable to the entire South African FMCG industry.
- Sample Size: While deemed adequate for EFA, the sample size of 102 is relatively modest, potentially limiting statistical power and generalizability.
- Cross-Sectional Data: The data were collected at a single point in time, preventing analysis of changes or causal relationships over time.
- Quantitative Focus: The study relies solely on quantitative data, potentially missing richer contextual insights that qualitative methods could provide.
- Sectoral and Technological Ambiguity: While the term "disruptive technologies" is used broadly, the study does not disaggregate insights based on specific technological verticals (e.g., AI vs. IoT vs. blockchain). Consequently, the results may conflate challenges and enablers that manifest differently across technological paradigms.

6.3. Future Research

Based on the findings and limitations, future research could explore the following:

- Mixed Methodology: Future studies should adopt a mixed-methods approach that combines structured surveys with qualitative interviews or focus groups. This would illuminate the socio-cognitive drivers behind resistance and provide richer organizational narratives, especially around leadership behavior and cultural inertia.
- Longitudinal Research: track organizations over time to understand how challenges and enablers evolve throughout the transformation journey and assess the long-term impact of adoption.
- Broader Scope: expand the research to include other provinces in South Africa or compare findings across different industries or emerging economies.
- Specific Technologies: investigate the adoption challenges and enablers related to specific disruptive technologies (e.g., AI, IoT) within the FMCG context in more detail.
- Sample Size: while the current sample size is generally deemed acceptable for EFA, future research could consider expanding the sample to enhance the generalizability of results, given the study's breadth and significance.
- Impact Measurement: develop and test frameworks for measuring the tangible and intangible impacts of digital transformation in the FMCG sector.
- Further exploration of differences in technology adoption across FMCG companies of varying sizes and regions could strengthen the study's representativeness.

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Abbreviations

The following abbreviations are used in this manuscript:

DT Digital Transformation

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