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

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Posted Date: 8 May 2025

doi: 10.20944/preprints202505.0555.v1

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

 doi:10.20944/preprints202505.0555.v1

Article

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, 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 & Resources Constraints' and 'Human Factors Constraints,' and enabling dimensions including 'Organizational Commitment & Strategy' and 'Leadership.' The study concludes with key implication for promoting successful adoption.

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. (2019) [3] assert that the manufacturing landscape has been, and will continue to be, reshaped by the pervasive influence of the internet and associated technologies and 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 meet their environmental obligtation. These technologies empower organizations to respond effectively to environmental changes, fostering the emergence of new competitive paradigms. Established organizations recognize the strategic importance of

 doi:10.20944/preprints202505.0555.v1

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, 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 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, significant challenges hinder adoption of sustainable digital transformation, this was further argued by (Broadbeant and Cara, 2018; Newman et al. [22,23], who stated that there is a need to adapt societies and organisation to this new world of uncertainty in the environment which results in the resistance of adoption of sustainable practices at the same time this cultural change process 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 behaviour understanding, data scarcity for justification, skill gaps, digital illiteracy, and security concerns (Hafsi and Assar, 2016; Solis and Szymanski, 2016; WEF, 2016)[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 (Ukko et al., 2019)[27].

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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 (Davenport and Westermann, 2018)[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 (Davenport and Westermann, 2018)[28]. These instances underscore that the path to sustainable digital transformation via disruptive technologies is complex, influenced by both enabling factors and significant challenges. This context forms the basis for this study, which seeks to explore the implementation of digital transformation using disruptive technologies within the South African Fast-Moving Consumer Goods (FMCG) industry, focusing specifically on the enabling factors and challenges encountered.

Thus, the study objectives are:

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 (Sebastian et al., 2012; Li et al., 2017; Hanelt et al., 2015a; Gunther et al., 2017; Du et al., 2016; Richter et al., 2017)[29–34] alongside others like blockchain (Glaser, 2017)[35] and foundational internet technologies (Lyytinen and Rose, 2003b)[36]. These technologies are often described as inherently disruptive (Karimi and Walter, 2015)[37]. Literature suggests three primary types of disruption stemming from these technologies:

Changing Consumer Behaviour and Expectations: Digital tools provide consumers with unprecedented access to information and communication, transforming them into active participants in dialogues with organizations (Kane, 2014; Yeow et al., 2017)[38,39]. Consumers feel less captive and demand more personalized and immediate services (Lucas Jr, et al., 2013; Sia et al., 2016)[40,41]. For example, the demand for mobile banking solutions pressured institutions like DBS Bank to innovate rapidly to remain competitive (Sia et al., 2016)[41]. 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 (Ciampi et al., 2021)[8].

2.2. Enabling Disruptive Technologies for Digital Transformation

Several key disruptive technologies are commonly cited as enablers of digital transformation processes (Bai et al., 2020; Osterrieder et al., 2020)[42,43]:

Artificial Intelligence (AI) and Machine Learning (ML): Enhance efficiency and effectiveness by enabling systems to learn, adapt, and solve problems autonomously within operational processes (Demirkan et al., 2016; Hartley & Sawaya, 2019)[44,45]. 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 (Borangiu et al., 2019; Cachada et al., 2019)[46,47].

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Cybersecurity: Crucial for protecting sensitive data (including customer data) and ensuring the integrity of digital systems amidst rising cyber threats (Heikkila et al., 2016; Mittal et al., 2019)[48,49]. 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 (Borangiu et al., 2019; Piccinini et al., 2015)[46,50].

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 (Castelo-Branco et al., 2019; Paritala et al., 2017)[51,52]. Digital Twin: Creates virtual replicas of physical assets, processes, or systems, enabling simulation, analysis, training, and optimization in a risk-free environment (Kritzinger et al., 2018)[53].

Robotics and Automation: Used to handle repetitive or hazardous tasks, improve efficiency, and enhance workplace safety, requiring careful integration with human workers (Agrawal & Narain, 2018; Demirkan et al., 2016)[44,54]. Enterprise Resource Planning (ERP) Systems: Integrate various business functions, facilitating real-time information flow. Cloud-based ERP systems offer enhanced flexibility and data accessibility (Lee et al., 2011)[55].

2.3. Challenges to Adopting Disruptive Technologies for Sustainable Digital Transformation

Despite the potential, adopting disruptive technologies for digital transformation faces numerous hurdles, particularly in emerging economies like South Africa. Increased competitive pressures necessitate digitization, yet the breadth and complexity of available technologies complicate strategic choices (Fitzgerald et al., 2014)[56]. Even large organizations can misstep (Gide and Wu, 2007)[57], and Small and Medium Enterprises (SMEs) often lag in leveraging digital opportunities (Fosty et al., 2013)[58].

Specific challenges include:

Resource Constraints: Emerging market firms often face institutional and infrastructural limitations (Tehssen et al., 2019)[59] alongside scarcity of financial capital and human resources (Goude and Oberg, 2016; Schr€oder, 2016; Fosty et al., 2013)[60,61]. High initial investment costs and difficulty measuring ROI deter adoption (Taiminen and Karjaluoto, 2015)[62].

Capability and Knowledge Gaps: Lack of internal expertise, limited understanding of operational contexts, insufficient digital literacy, and a shortage of talent capable of implementing new digital business models are significant barriers (Taiminen and Karjaluoto, 2015)[62].

Organizational and Cultural Factors: Resistance to change, rigid organizational structures (silos), poor management attitudes towards digital technologies, lack of a supportive digital culture, and inadequate training impede transformation (Andersson et al., 2018; Yoo et al., 2010)[63,64].

Strategic Deficiencies: Lack of a clear strategic vision for digital transformation, poor collaboration across departments or with external partners, and inability to develop agile business models hinder progress [60]. Defining a unifying strategic vision and ensuring strong leadership are critical but challenging.

Technical and Infrastructural Issues: Lack of access to necessary digital technologies, poor existing infrastructure, and difficulties integrating new systems with legacy platforms pose technical barriers (Tehssen et al., 2019)[59].

External Factors: Legal and regulatory hurdles, data privacy concerns, and market uncertainty can also slow adoption (Andersson et al., 2018; Hafsi and Assar, 2016)[24,63].

These challenges highlight the complexity of digital transformation, requiring more than just technology deployment; it demands strategic, organizational, and cultural shifts.

2.4. Enabling Factors that Drive Sustainable Digital Transformation

The growing use and transformative nature of DIT have significantly changed the way businesses operate and how they compete and interact with others. These changes have also influenced customer and end-user behaviors and expectations. As a result, organizations are increasingly compelled to adopt and utilize DIT to take advantage of the opportunities it offers (Hartl

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and Hess, 2017)[65]. Many organizations recognize the importance of transforming their operations to remain relevant and competitive, and to keep pace with the digital advancements in their industry. Berghaus and Back (2017)[66], explored the reasons why different organizations implement DT programs and discovered various motivating factors, regardless of industry or company size. These drivers can be categorized as either external or internal triggers that prompt organizations to engage in DT. Organizations have expressed the need to keep up with the digital changes happening in their respective industries. DT is often initiated by shifts in customer behaviors and expectations (Haffke et al., 2017; Schmidt, Drews, and Schirmer, 2017)[67,68], digital advancements within the organization's industry, and changes in the competitive landscape (Berghaus and Back, 2017)[66].

Organizations are encountering new challenges in the competitive landscape as they compete not only with traditional rivals but also with a growing number of non-industry players (Berghaus and Back, 2017; Piccinini, Hanelt, Gregory, and Kolbe, 2015)[50,66]. Additionally, organizations are feeling the pressure to embrace digitalization due to the advancements demonstrated by their competitors, the emergence of disruptive digital business models from new market entrants, and overall technological progress. These factors are driving companies to undergo comprehensive organizational transformations (Haffke et al., 2016)[67]. Moreover, due to the significant pressure, the organization decided to demonstrate its commitment to digital transformation by creating a dedicated department responsible for driving the DT initiatives (Haffke et al., 2016)[67].

According to (Berghaus and Back, 2017)[66], organizations have been confronted with regulatory changes that have compelled them to reconsider their business practices and undergo organizational transformations. In their study, (Berghaus and Back, 2017)[66] found that one of the drivers of DT is organizations' desire to ensure digital readiness. This means that organizations want to be prepared for changing circumstances and be able to respond quickly when necessary. The goal of digital readiness is to improve existing products (Mocker and Fonstad, 2017)[69], drive product innovation (Berghaus and Back, 2017)[66], and explore and develop new, potentially disruptive, business models to remain competitive and generate additional revenue.

According to (Berghaus and Back 2017 and Mocker and Fonstad 2017)[66,69], another motivating factor for implementing digitalization is the desire to enhance digital channels and customer-facing processes, as well as provide updated digital products. This is done to meet the evolving expectations and behaviors of customers, and to improve and maintain customer satisfaction and communication (Berghaus and Back, 2017; Bilgeri et al., 2017; Isaksson and Hylving, 2017; Mocker and Fonstad, 2017)[66,69–71]. Additionally, organizational culture is identified as one of the drivers that can influence the process and outcome of DT (Mueller and Renken, 2017)[72]. To ensure the success of DT, the organization needs to cultivate a supportive culture that encourages collaboration between business and IT initiatives (Haffke et al., 2017)[67]. This notion is further supported by the findings of Hartl and Hess (2017)[65], who conducted a Delphi study to explore the cultural values that are essential for DT success. The study identified two key organizational values: openness to change, which involves being receptive to new ideas and embracing change, and customer centricity, which entails designing activities to meet customer needs. It is believed that organizations that prioritize openness to change foster a mindset that is receptive to, promotes, and implements change, which is crucial for achieving successful DT (Hartl and Hess, 2017)[65].

According to (Hartl and Hess, 2017)[65], organizational values that promote innovation, a willingness to learn, tolerance of failure, risk-taking, and an entrepreneurial mindset were highlighted as important for DT success. Additionally, trust, participation, cooperation, and effective communication were identified as crucial elements of organizational culture. The study suggested that an agile culture, which prioritizes adaptability over control, is essential to support DT initiatives. This includes embracing both internally and externally driven values that foster agility within the organization.

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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 Everett Rogers (2014, 2003, 2004)[73–75]. 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?)

Applying DOI to FMCG Digital Transformation:

DOI provides a valuable framework for analysing 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.

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 (Shahid, 2022; Iqbal & Zahidie, 2022)[76,77]. 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,

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aligning with the study's objectives. The use of a questionnaire facilitated efficient data gathering from a geographically dispersed sample within a limited timeframe (Tan, 2011)[78].

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 organisations.

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 (e.g., Hair et al., 2011; Osborne, Costello & Kellow, 2008)[79,80]. 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: Demographic information of the respondents.

Section 2: 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 (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 analysed 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. 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 (Field, 2009)[81].
- 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).
- Interpretation: Items were considered to load significantly on a factor if their loading was ≥ 0.40, following common guidelines (Stevens, 2002; Hair et al., 2011)[79,82]. Communalities were checked to ensure variables shared sufficient variance with the extracted factors (values > 0.4 often considered acceptable, Osborne, Costello & Kellow, 2008)[80].

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4. Findings and Discussion

4.1. 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.

4.1.1. 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 ($\bar{X}$ = 4.91). Other highly ranked challenges include 'Lack of ability to develop new business models' ($\bar{X}$ = 4.90), and several factors tied at rank 4 ($\bar{X}$ = 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. This is a table. Tables should be placed in the main text near to the first time they are cited.

Challenge	Mean ($\bar{X}$)	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 organisational 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

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4.1.2. 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 ($p < .001$), 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 labelled based on the items loading significantly onto them:

- Factor 1: Infrastructural and Resources Constraints: This factor grouped items related to 'Institutional constraints,' 'Infrastructural constraints,' 'Lack of resources,' and 'Lack of capabilities.' Rationale: This label reflects the combined impact of external institutional hurdles and internal limitations in physical infrastructure and general resources.
- Factor 2: Poor Digital Infrastructure: This factor primarily comprised 'Lack of access to digital technologies.' Rationale: This highlights the specific barrier of inadequate access to foundational digital tools
- Factor 3: Human Factors Constraints: 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: Inability to Develop Business Models: 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: Lack of Agile Capability: 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: Weak Top Management and Organizational Culture: This factor included 'Limited commitment from top management' and 'Poor organizational culture.' Rationale: This highlights the combined negative influence of unsupportive leadership and an unsuitable organizational environment.
- Factor 7: Lack of Organizational Commitment: This factor was primarily represented by 'Lack of organizational commitment.' Rationale: This singles out the general lack of buy-in or dedication from the organisation as a whole.
- Factor 8: Inability to Integrate Systems Vertically: This factor consisted of 'Limited ability to vertically integrate systems.' Rationale: This points to the technical challenge of connecting different operational systems.

4.1.3. Discussion of Challenges

The high ranking of 'High initial cost' aligns with literature identifying financial constraints as a major barrier, especially in emerging markets. This finding aligns with previous research that has highlighted resource constraints as a significant barrier to technology adoption in emerging economies (Taiminen and Karjaluoto, 2015)[62]. The EFA factor 'Infrastructural and Resources Constraints' further supports this, echoing findings by Tehssen et al. (2019)[59] on infrastructural limits and Goude and Oberg (2016)[60] on resource scarcity. 'Poor collaboration' and the EFA factor 'Lack of Agile Capability' highlight organizational process issues. The challenge 'Lack of ability to develop new business models' (also Factor 4 in EFA) corresponds directly with Wolcott et al. (2018)[85] regarding insufficient talent or capability for digital business model innovation.

Challenges related to human elements like 'Limited expertise,' 'Lack of human resources,' 'Poor attitude,' and 'Lack of definite timeline' (ranked highly descriptively and grouped under 'Human Factors Constraints' in EFA) resonate with findings by Taiminen and Karjaluoto (2015)[62]. 'Poor organizational culture' and 'Limited commitment from top management' (highly ranked and

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grouped in EFA Factor 6) align with Schroeder (2016)[61] and Andersson et al. (2018)[63], emphasizing the critical role of leadership support and a conducive culture.

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.

4.2. 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.

4.2.1. Descriptive Analysis of Enabling Factors

Table 2. ranks the enabling factors based on their mean item score ($\bar{X}$).

Enabling Factors	Mean ($\bar{X}$)	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 behaviour	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

'Top management commitment' emerged as the most crucial enabling factor ($\bar{X}$ = 4.93), followed closely by 'Cost reduction of operations' ($\bar{X}$ = 4.91) and 'Integration of systems' ($\bar{X}$ = 4.89). Other important enablers include 'Organization commitment,' 'Strategy and strategic goals,' and 'Employee support' (all $\bar{X}$ = 4.86). Factors like 'Competitive advantage' and 'New market entrants' were ranked lower but still received high agreement scores, indicating their relevance.

4.2.2. 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 ($p < .001$), supporting factorability. Communalities were generally acceptable,

 doi:10.20944/preprints202505.0555.v1

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

- Factor 1: Organizational Commitment and Strategy: 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: Leadership and Market Responsiveness: Included 'Cost reduction,' 'Market pressure,' and 'Leadership.' Rationale: Captures leadership driving efficiency gains likely spurred by external market forces.
- Factor 3: Organisational Culture, Readiness, and Legislation: Grouped 'Digital readiness,' 'Organizational culture,' and 'Legislation.' Rationale: Represents the interplay between internal preparedness (culture, readiness) and external regulatory influences.
- Factor 4: Customer Expectations and Market Disruption: 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 Commitment and Competitive Advantage: Grouped 'Resource commitment' and 'Competitive advantage.' Rationale: Links the allocation of necessary resources to the strategic goal of gaining a competitive edge.
- Factor 6: Changing Customer Behaviour: Primarily consisted of 'Changing customer behaviour.' Rationale: Isolates the specific influence of shifts in how customers interact and make purchases

4.2.3. Discussion of Findings Through the Lens of DOI Theory

Furthermore, the study seek to align the findings to Rogers Diffusion of Innovation:

Challenges to the adoption of DT.

- High Initial Costs: This directly affects *relative advantage*. If firms perceive the cost of adoption to be too high, the perceived advantage of the new technology is diminished, hindering adoption.
- Poor Collaboration: This relates to *compatibility and observability*. Lack of collaboration can make it difficult for firms to see how the technology fits with their existing systems and how others are benefiting from it.
- Resource Constraints: This broadly affects *trialability* and *complexity*. Limited resources may prevent firms from experimenting with new technologies or make the adoption process seem overly complex.
- Capability and Knowledge Gaps: This increases the perception of *complexity*. If staff lack the skills to use a technology, it will be seen as more complex and less likely to be adopted.
- Organizational and Cultural Factors: Resistance to change reduces *compatibility*. If the technology is not seen as fitting in with the existing culture, it will be resisted.
- Strategic Deficiencies: A lack of clear vision reduces *relative advantage* and *compatibility*. Without a clear strategy, the benefits of the technology may not be apparent, and it may not align with the firm's goals.
- Technical and Infrastructural Issues: Poor infrastructure reduces *trialability* and increases *complexity*. If the infrastructure isn't in place, firms can't easily experiment with the technology, and adoption becomes more complex.
- External Factors: Issues like legal and regulatory hurdles affects *compatibility*.

Findings from the EFA findings

- **Infrastructural and Resource Constraints:** This factor relates to *compatibility* and *trialability.*

Lack of resources and infrastructure makes it harder for firms to try out new technologies or integrate them into existing systems.

Institutional constraints can affect the perceived *relative advantage* if they create an unsupportive environment for innovation.

- **Poor Digital Infrastructure:** This is a fundamental issue of *compatibility.*

If the basic digital infrastructure is lacking, adoption is hindered because the innovation can't be easily integrated.

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- **Human Factors Constraints**: This strongly connects to *complexity*.

  Lack of expertise, poor attitudes, and lack of timelines increase the perceived difficulty of adopting new technologies.
- Inability to Develop Business Models: This affects *relative advantage.*

  If firms can't see how the technology will improve their business model, they won't perceive a strong advantage.
- **Lack of Agile Capability:** This relates to *compatibility.*

  If an organisation lacks agility and collaboration, it's less compatible with the change required for digital transformation.
- **Weak Top Management and Organizational Culture:** This influences *compatibility* significantly.

  Lack of commitment and a poor culture create an environment that is incompatible with innovation.
- **Lack of Organizational Commitment:** This is a general issue of *adoption* and relates to all DOI characteristics.

  Without commitment, firms are less likely to invest resources, address complexity, or see the relative advantage.
- **Inability to Integrate Systems Vertically:** This is a compatibility issue. If systems can't be integrated, the innovation is less compatible with existing technology.

Enabling Factors as Facilitators of Adoption

- **Top Management Commitment:** This enhances *relative advantage*, *comaptiabiltiy* and *observability*. when top management is committed, resources are more likely to be allocated, the technology is seen as more important and its benefits are more likely to be visible.
- **Operational Cost Reduction:** This directly increases *relative advantage*. If a technology can reduce costs, firms are more likely to see it as advantageous.
- **Digital Readiness:** This enhances *compatibility*. Firms that are digitally ready will find it easier to integrate new technologies into their existing systems.
- **Customer Focus:** This increases relative advantage. Technologies that improve customer satisfaction will be seen as advantageous.
- **Culture of Innovation:** This enhances trialability, compatibility, and openness to change. A culture that values innovation will be more willing to experiment with new technologies and see them as compatible with their values.

Findings from the EFA Findings

- **Organisational Commitment and strategy:** This strongly influences *relative advantage*, *compatibility*, and *complexity*. Clear strategy and commitment increase the perceived advantage by aligning the technology with business goals. It also improves compatibility by ensuring the technology fits with the organization and reduces complexity by providing direction.
- **Leadership:** This is key for relative advantage, *compatibility*, *complexity* and *observability*. Strong leadership can articulate the advantage, create a compatible environment, provide resources to reduce complexity, and make the benefits of adoption more visible.
- **Operational Capabilities:** This relates to *relative advantage, trialability* and *complexity*. Factors like cost reduction and efficiency gains directly increase the relative advantage. Improved capabilities can make it easier to trial and implement technologies, reducing complexity.
- **Digital Capabilities:** This is primarily about reducing complexity and improving trialability. Having digital skills and infrastructure makes the technology easier to understand and implement.
- **Strategic Agility:** This enhances *relative advantage* and *compatibility.* Agility allows firms to adapt the technology to their needs and changing environments, increasing its advantage and compatibility

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5. 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.

- Objective 1 (Challenges): The study successfully identified key challenges. High initial cost and poor collaboration were ranked highest descriptively. EFA revealed underlying dimensions including infrastructural and resource constraints, human factor constraints, lack of agile capability, and weak leadership/culture. These findings largely align with international literature, suggesting South African FMCG firms face similar, potentially intensified, barriers related to cost, infrastructure, skills, culture, and strategy. Furthermore, the findings were interpreted through the lens of Roger's Diffusion of Innovation theory. The key challenges identified such as initial costs and poor collaboration, directly hinder the adoption process by reducing the relative advantage, compatibility, and trialability of disruptive technologies.
- Furthermore, the EFA results highlight how the factors influencing disruptive technology adoption in the South African FMCG sector align with DOI's characteristics of innovation. Challenges such as 'Infrastructural and Resource Constraints' and 'Poor Digital Infrastructure' hinder *compatibility* and *trialability*, making it difficult for firms to integrate and experiment with new technologies. '*Human Factors Constraints'* and 'L*ack of Agile Capability'* increase the perceived *complexity* of adoption and reduce organizational *compatibility* with change. '*Weak Top Management and Organizational Culture'* and 'L*ack of Organizational Commitment'* create a fundamental lack of *compatibility* and negatively impact the perception of *relative advantage*.
- Objective 2 (Enablers): The study also successfully identified key enabling factors. Top management commitment, cost reduction goals, and systems integration were ranked highest descriptively. EFA identified dimensions such as organizational commitment and strategy, leadership and market responsiveness, customer focus, and resource commitment linked to competitive advantage. These findings highlight the critical role of internal leadership, strategic alignment, operational benefits, and external market awareness in driving successful adoption. Conversely, enabling factors like top management commitment and a culture of innovation facilitate adoption by enhancing these same attributes. For instance, top management commitment signals a strong relative advantage and compatibility, making organizations more likely to embrace new technologies.
- Furthermore, the EFA results highlight how the factors influencing disruptive technology adoption in the South African FMCG sector align with DOI's characteristics of innovation. 'Organizational Commitment and Strategy' and 'Leadership' enhance the *relative advantage* by providing clear goals and direction, improve *compatibility* by aligning technology with the organization, and reduce *complexity* by providing resources and support. 'Operational Capabilities' and 'Digital Capabilities' further contribute to *relative advantage* through efficiency gains and reduce *complexity* by providing the necessary skills and infrastructure. 'Strategic Agility' ensures *compatibility* and *relative advantage* by enabling firms to adapt and respond to change.

From the findings for instance to mitigate the challenge of high initial costs, the government could offer tax incentives or subsidies for technology adoption. Furthermore, industry associations could facilitate collaboration among FMCG companies to share resources and best practices, thereby reducing the burden of adoption.

Specifically, South African FMCG firms' adoption of disruptive technologies is often hampered by a lack of relative advantage due to high initial costs and difficulties in observing the benefits (observability) due to poor collaboration. Addressing these challenges by, for example, providing financial incentives to increase relative advantage and promoting industry collaboration to improve observability, could significantly accelerate the diffusion process. Furthermore, efforts to improve

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digital readiness and foster a culture of innovation would enhance compatibility and trialability, making these technologies more likely to be adopted.

In conclusion, by understanding the adoption of disruptive technologies through the framework of DOI theory, FMCG companies can better strategize to overcome barriers, leverage enablers, fostering an environment where disruptive technologies are perceived as having high *relative advantage*, *compatibility*, *trialability*, and *observability*, while minimizing *complexity*, is crucial to achieve successful digital transformation.

5.1. Practical Implications

The findings offer several insights for managers and policymakers in the South African FMCG sector:

- Prioritize Leadership & Strategy: Strong, committed leadership is paramount. Organizations need a clear, well-communicated digital transformation strategy that aligns with business goals.
- Address Resource & Skill Gaps: Strategies must realistically account for high initial costs and seek ways to mitigate them (e.g., phased implementation, cloud solutions). Investment in training and upskilling the workforce is crucial to overcome expertise limitations.
- Foster Collaboration & Agility: Efforts should focus on breaking down internal silos, improving cross-functional collaboration, and cultivating an organizational culture that embraces change and agility.
- Focus on Value Creation: Clearly articulate and measure the expected value (e.g., cost reduction, efficiency gains, improved customer experience) to justify investments and maintain organizational commitment.
- Leverage External Drivers: Use market pressure and changing customer expectations as catalysts for change, ensuring transformation efforts are customer centric.

5.2. 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

5.3. Future Research

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

- Qualitative Studies: Conduct in-depth case studies or interviews within South African FMCG firms to gain richer insights into the nuances of challenges, success factors, and organizational dynamics during digital transformation.
- 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.
- Impact Measurement: Develop and test frameworks for measuring the tangible and intangible impacts of digital transformation in the FMCG sector.

 doi:10.20944/preprints202505.0555.v1

Acknowledgments: During the preparation of this manuscript/study, the author(s) used [Gemini} for the purposes of language editing and reviewing the strength and weakness of the writing style. The authors have reviewed and edited the output and take full responsibility for the content of this publication.

Conflicts of Interest: The author declares no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

DT Digital Transformation

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