Technology Drivers of Innovation Competitiveness in Biotechnology Entrepreneurship in Gauteng, South Africa

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DECLARATION

I, Sibahle Tile, hereby declare that this research report for the Master of Business Administration submitted to the Faculty of Commerce, Law and Management at the University of Witwatersrand has not been submitted previously for any degree at this or another university. It is original in design and in execution, and all reference material contained herein has been duly acknowledged.

Student…….S Tile……. Date: ….26 February 2024……

DEDICATION

I dedicate this dissertation as a testament to the legacy of my late father. I embark on this academic journey with a profound sense of longing and curiosity about the man you were. Your untimely departure cast a shadow on my life, and yet, through the stories and memories shared by those who knew you, I have come to recognize the profound impact you had on the lives of others. I hope I have made you proud. To the cherished memories of my beloved grandmother, who raised me from a young age and allowed me to dream. Your unwavering support and influence shaped the very essence of who I am. You believed and instilled in me the courage to pursue my dreams and the resilience to overcome every obstacle.

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ABSTRACT

Biotechnology entrepreneurship is a rapidly growing field with significant potential for economic development and innovation. However, most of the existing empirical research in this field has been conducted in developed economies, which may not directly apply to the unique context of developing economies like South Africa. In developing countries, including South Africa issues related to human health, food security, renewable resources, and environmental sustainability that biotechnology solutions address are more prevalent, alongside challenges of socio-economic development, unemployment, and low global competitiveness. These challenges emphasize the significance of entrepreneurship, particularly biotechnology entrepreneurship, in developing countries. This study aimed to investigate the drivers influencing innovation competitiveness in biotechnology entrepreneurship and evaluate the relevance and effectiveness of technology push and demand-pull innovation of biotechnology entrepreneurship in Gauteng, South Africa.

The research adopted a qualitative approach and was conducted through fourteen virtual one-on-one interviews with semi-structured questions. Purposive sampling was used to select biotechnology entrepreneurs involved in the agriculture and health biotechnology sectors with innovations in the biopharmaceuticals, agritech, agroprocessing medical devices and diagnostics industries. The data collected from the participants in the interviews was then thematically analysed to draw a conclusion based on the findings.

Main findings included: key drivers influencing innovation competitiveness within the biotechnology entrepreneurship sector in South Africa, emphasizing access to the market, funding, government support, regulatory compliance, and specific market trends as crucial factors. Participants highlighted the significance of market access, government funding, and adherence to regulatory standards for innovation. Additionally, the study explored market, entrepreneurial, and technological capabilities essential for commercializing biotechnology innovations in Gauteng, stressing the importance of entrepreneurial acumen, market understanding, and technological proficiency. It also outlined key enablers such as a growing market and resource availability, alongside constraints like limited funding, skills shortages, and regulatory complexities. The study illustrated how challenges such as access to funding, skills shortages, and unrealistic regulatory standards hinder innovation within the technology push model, while opportunities such as a growing market and potential government support serve as enablers within the demand-pull model, fostering a conducive environment for innovation.

Key Words: Biotechnology, innovation competitiveness, entrepreneurship, commercialisation, technology push, demand pull, bioeconomy, innovation ecosystem.

Journal Nomination

I intend to nominate the ‘African Journal of Innovation and Entrepreneurship’ as a potential outlet for the publication of the research findings presented in this dissertation, given its focus on innovation and entrepreneurship and the alignment of my study with its scope.

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CHAPTER 1: INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Entrepreneurship serves as a key driver behind societal well-being, wealth creation, and is a major contributor to economic growth in the country, accounting for more than 40% of overall GDP and 87% of all employment (OECD, 2022). It is regarded as critical to realizing the growth potential of the industry of biotechnology. Entrepreneurship has the capacity to tackle critical societal issues, including the UN Sustainable Development Goals (SDGs) and the economic recovery following the COVID-19 pandemic (Bowmaker-Falconer & Meyer, 2022).

According to the Global Entrepreneurship Monitor (GEM), South Africa scored 45th position among 50 countries on GEM's National Entrepreneurship Context Index in 2021, which measures how conducive the environment is for entrepreneurship and the development of new businesses. When comparing this score with other countries, the likelihood of being an entrepreneur is two to three times higher in Brazil, India, and China than it is in South Africa (Bowmaker-Falconer & Meyer, 2022). As a result, the economy's structural transformation is stagnant, which makes it reliant on sectors such as mining and agriculture (Vabaza, 2022).

In addition to tackling societal challenges, which now include the economic disruption caused by the COVID-19 outbreak - entrepreneurship stimulates the innovation needed to take advantage of untapped opportunities, enhance productivity, and to create jobs (Bowmaker-Falconer & Meyer, 2022). Moreover, the country has implemented policies and initiatives to foster entrepreneurship, such as the National Development Plan, which prioritizes small and medium-sized enterprises (SMEs) as catalysts for inclusive economic development.

South Africa has yet to make significant strides in establishing entrepreneurship as an essential driver of economic growth, employment creation, and social cohesion. Since 2011, there has been a decline in the growth of real GDP per capita, indicating that the economy has continuously underperformed for more than ten years (Bowmaker-Falconer & Meyer, 2022).

Given the recent and ongoing global pandemic, this situation seriously calls for a more dynamic employment-intensive and innovation-led growth trajectory, which will require a prioritized and more directed policy framework at the national and regional levels. A focus on entrepreneurship

would stimulate the growth of more successful businesses and formalize many aspects of the South African economy (Bowmaker-Falconer & Meyer, 2022).

The world is undoubtedly moving towards a knowledge economy with biotechnology playing a significant role. According to international standards, South Africa's biotechnology sector is still in its infancy (Jordaan, 2009). Growing a robust biotechnology sector in South Africa is therefore crucial if the country is to be competitive in the nascent knowledge economy. In view of this, the National Biotechnology Strategy was developed, and it is this strategy that continues to inform all government incentives for biotechnology.

According to the Bioeconomy Strategy of 2013, the goal is for South Africa's bioeconomy to contribute significantly to South Africa's economic growth by 2030. This will be executed through the advancement of novel businesses that produce and create bio-based services, goods, and innovations. Such efforts should translate into a proportional rise in new businesses and expansion of existing businesses that offer and make use of these solutions.

Biotechnology commercialization in South Africa has been gaining momentum over the past few years, with the sector having grown at 8.3% of the total GDP in 2020 (NACI, 2020). One of the key drivers of biotechnology commercialization in South Africa is the presence of a strong research and development infrastructure. The country has several world-class research institutions, universities, and laboratories that are actively engaged in biotechnology research. This has resulted in the growth of a workforce that is highly skilled and well-equipped to drive innovation and commercialization in the field (Cloete et al., 2006).

In addition to a strong research base, South Africa has also implemented a number of policies and initiatives aimed at promoting biotechnology commercialization. For example, the government has established a few technology transfer offices that are responsible for facilitating the transfer of technology and intellectual property from universities and research establishments to private sector. Additionally, there are numerous tax incentives and funding programs available to support biotechnology start-ups or entrepreneurs and small businesses (DST, 2013).

Furthermore, for the last two decades South Africa has preferred to acquire rather than develop its own products. Due to the sanctions imposed during the apartheid era, the South African government was forced to invest in its own resources, which led to the development of top-tier science and technology by South African scientists. However, post-apartheid, the government

has found sourcing of technologies from other countries easier than investing in its own technologies (Uctu & Eksteen, 2022).

Overall, the biotechnology sector in South Africa is poised for continued growth and innovation in the years to come, driven by a combination of strong research capabilities, supportive policies and initiatives, and a growing pool of skilled professionals and entrepreneurs.

1.2 PROBLEM STATEMENT

Biotechnology entrepreneurship is a rapidly growing field with significant potential for economic development and innovation. However, most of the existing empirical research in this field has been conducted in developed economies, which may not directly apply to the unique context of developing economies like South Africa (Alagbaoso et al., 2015). In developing countries, including South Africa issues related to food security, human health and environmental sustainability that biotechnology solutions address are more prevalent, alongside challenges of unemployment, socio-economic development and low global competitiveness. These challenges emphasize the significance of entrepreneurship, particularly biotechnology entrepreneurship, in developing countries (Abdullahi & Mu'azu, 2023).

Additionally, South Africa is a country with immense biodiversity and a growing biotechnology sector, but it faces distinct socio-economic challenges, such as high levels of inequality and poverty (Vally & Motala, 2017). With a Gini index of 63 and the largest income distribution inequality in 2021. Moreover, in 2022, estimates suggest that 18.2 million South Africans fall into the category of extreme poverty (Statista, 2023). These socio-economic challenges limit the availability of resources for aspiring entrepreneurs, including those in the biotechnology sector (Vally & Motala, 2017).

This research study aims to address the gap in knowledge by investigating the drivers of innovation specific to entrepreneurship in Gauteng, South Africa. By conducting a comprehensive study, this research will provide insights into how South Africa can harness the potential of its biotechnology sector to drive economic growth, attract investment, and create employment opportunities. The research can also help in identifying strategies to overcome resource constraints faced by aspiring biotechnology entrepreneurs, thereby promoting inclusive economic development.

1.3 AIM OF THE STUDY

The aim of this research is to investigate the drivers influencing innovation competitiveness in biotechnology entrepreneurship and evaluate the relevance and effectiveness of technology push and demand-pull innovation of biotechnology entrepreneurship in Gauteng, South Africa.

1.4 RESEARCH QUESTIONS

This study will contribute to answering three main questions of the study which are:

i. What key drivers influence innovation competitiveness within the biotechnology entrepreneurship sector in South Africa?
ii. What market, entrepreneurial, and technological capabilities drive the commercialization of biotechnology innovations in the context of entrepreneurship in Gauteng, South Africa?
iii. What are the key enablers and constraints related to technology drivers in biotechnology entrepreneurship, and how do they impact the technology push and demand-pull models of innovation?

1.5 OBJECTIVES OF THE STUDY

Specifically, the research is undertaken with the objective:

i. To explore the key drivers of innovation in the biotechnology entrepreneurship sector in South Africa.
ii. To gain insights into the role of market, entrepreneurial and technological capabilities in driving commercialisation for biotechnology innovations as they relate to entrepreneurship in Gauteng, South Africa.
iii. To examine the enablers and constraints with respect to technology drivers of innovation in biotechnology entrepreneurship and their impact on technology push and demand-pull models.

1.6 JUSTIFICATION OF THE STUDY

Contribution towards economic growth: The biotechnology sector has the ability to alleviate some of the historical and socioeconomic inequities in the country through skilled job development, international partnerships for skills transfer, and export prospects. Understanding the drivers of innovation specific to this context can provide valuable insights into how entrepreneurs navigate and overcome challenges, ultimately contributing to the success and growth of the biotechnology sector.

A thriving biotechnology sector has the potential to draw young students towards science and technology education, thereby aiding in the reduction of the skills gap in the labour market and addressing youth unemployment in South Africa.

Addressing Knowledge Gap: While there is a significant body of literature on innovation and entrepreneurship, comprehensive research specifically centred on entrepreneurship in the biotechnology field in South Africa is notably lacking. This study aims to bridge that knowledge gap by exploring and identifying the key factors that contribute to innovation in this particular sector within the country.

Policy Implications: The outcomes of this research could hold significant policy implications. By identifying the key drivers of innovation, policymakers can develop targeted strategies and policies to support and promote biotechnology entrepreneurship in South Africa. This, in turn, can foster economic growth, job creation, and technological advancement in the country.

Practical Insights for Entrepreneurs: The study aims to provide practical insights for biotechnology entrepreneurs in South Africa. By understanding the factors that influence innovation outcomes, entrepreneurs can make informed decisions regarding their commercialisation strategies. This knowledge can enhance their chances of success and growth in the competitive biotechnology sector.

1.7 DELIMITATIONS OF THE STUDY

The perspective adopted in the study is delimited to the following:

Geographic Scope: the study focuses specifically on Gauteng, South Africa, and does not encompass other provinces within the country.

Industry Focus: the research is limited to the field of biotechnology, which covers the following sub-sectors: health, agriculture and industrial environment. The study does not explore other sectors or industries within the broader field of technology commercialization.

Data Availability: The analysis is dependent on the availability of relevant data and resources within the Gauteng region. Limitations in data accessibility may impact the comprehensiveness of the study.

Research Methodology: The study employs an analysis approach to examine technology push and demand-pull drivers. The research does not delve into other methodologies or approaches for analysing innovation management strategies or technology commercialization.

Sample Selection: The research will focus on a specific sample size or a predetermined selection of biotechnology entrepreneurs in Gauteng. The size and composition of the sample may influence the generalizability of the findings.

1.8 OPERATIONAL DEFINITIONS

The following operational definitions are adopted in the context of technology commercialisation for biotechnology entrepreneurship:

Bioeconomy and Biotechnology:

The concept of bioeconomy refers to undertakings that leverage biologically derived resources, processes, and inputs to establish environmentally, socially, and economically sustainable development (Department of Science and Technology, 2013). In contrast, biotechnology is the application of technical and scientific concepts to the biological processing of materials to create products and services (McKelve et al., 2004). Bioeconomy will be used to describe the broader sector and activities undertaken through biotechnology while biotechnology will be analysed as an industry which impacts the health, agriculture and environment sectors.

Technology Push and Demand Pull:

The term "technology push" describes the process wherein technological or scientific advancements serve as the driving force behind innovation. This strategy is generally adopted by scientists or inventors focus on creating a new technology without necessarily taking market demand or commercial viability into account. Demand pull, on the contrary, describes innovation that is fuelled by consumer needs or market demand. This strategy involves the identification of a technical gap in the market and developing a technology or a solution to fill that gap (Friedman, 2009). These concepts will be used in the context of technology innovation models.

Entrepreneurship:

This paper recognizes that there are multiple definitions of entrepreneurship from various perspectives. However, the study will focus on entrepreneurship that represents the Schumpeterian concept of creative destruction: where inferior solutions are partially or entirely replaced by novel products, services, and business models (Bowmaker-Falconer & Meyer, 2022). The concept of entrepreneurship will be used in the context of describing biotechnology as activities that are essential in the development of a successful biotechnology company, also known as “biotechnology entrepreneurship”.

Technology Commercialisation:

Commercialisation is the process that seeks to enhance the synergy between science and the economy through technology transfer. Commercialisation is driven by a range of factors such as infrastructure, technology, social, political, and historical considerations (Dehghani, 2015). In this paper commercialisation will be used in the context of science and technology which would involve the process of developing a suitable product or technology, based on scientific knowledge in order to satisfy market demand.

Innovation Ecosystem:

The phrase "ecosystem," which comes from biology, describes a network of interdependent businesses that rely on each other's operations. This study acknowledges that there are three general categories of ecosystem descriptions: business ecosystem, innovation ecosystem, and platform ecosystem. However, the study will solely concentrate on the innovation ecosystem, which can be described as innovation or a new value proposition and the ensemble of actors that support it (Bowmaker-Falconer & Meyer, 2022).

1.9 ASSUMPTIONS

- The selected sample of biotechnology entrepreneurs is representative of the broader biotechnology entrepreneurship landscape in Gauteng, South Africa.
- It is assumed that insights from developed economies, while adjusted for local context, are partially applicable and provide a useful comparative perspective for understanding the drivers of innovation competitiveness in Gauteng.
- It is assumed that the technology push and demand-pull models are appropriate frameworks for analysing the factors influencing biotechnology entrepreneurship in this context.
- The socio-economic and regulatory conditions in Gauteng remain stable during the study period and are reflective of typical conditions for biotechnology entrepreneurs.

1.10 STRUCTURE OF DISSERTATION

The structure of the research report is as follows:

- Chapter 1 provides an introduction and background of the study.

- Chapter 2 presents an overview of pertinent scholarly literature relating to the key drivers of innovation in the biotechnology sector, market, entrepreneurial and technological capabilities in driving commercialisation for biotechnology innovations and technology push and demand-pull innovation models. The analytical framework underpinning the study is also unpacked.
- Chapter 3 describes the study's research methodology for data collection and analysis.
- Chapter 4 summarizes and interprets the data collected.
- Chapter 5 concludes the study and suggests recommendations for further research.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

The literature review explores innovation in the biotechnology sector, focusing on its significance for entrepreneurship and the key factors contributing to innovation. It discusses the concept of innovation, its adoption through commercialization, and the impact of elements like entrepreneurial orientation, technology capabilities, and market orientation. The review also demonstrates the intricacy of the innovation process. in the biotechnology sector, including the role of various entities such as large corporates, emerging biotech companies, government research institutions, and universities. The National System of Innovation (NSI) in South Africa and its role in managing biotech innovations are examined. Furthermore, the global perspective of the biotechnology industry, including market sizes in Europe, the USA, and India and the African perspective is discussed. The review also provides an overview of government policies and initiatives promoting innovation in biotechnology, as well as the biotech landscape in the country. It examines the barriers to entry in the industry. Overall, the review presents a comprehensive analysis of innovation in the biotechnology sector from various perspectives and geographical contexts. The subsequent sections introduce the Schumpeterian and the integrated innovation management theoretical frameworks and a conceptual framework, with biotechnology entrepreneurship as a dependent variable and technology drivers as the independent variable.

2.2 INNOVATION IN THE BIOTECHNOLOGY SECTOR

2.2.1 The concept of innovation and its significance for entrepreneurship

Innovation is a notion that includes the idea creation process of an invention, known as the "science push," as well as its adoption, which typically occurs through commercialization. Almost all successful technology-based businesses rely heavily on innovation. An organization's capacity for idea generation may be affected by elements like its entrepreneurial orientation and/or technology capabilities. Additionally, there are factors like market orientation that may have an impact on how an invention is commercialized after it has been developed (Renko et al., 2019).

Innovation in the biotechnology sector involves the application of scientific advancements and technological breakthroughs to develop novel solutions in the fields of health, agriculture and

industrial biotechnology. High levels of research and development (R&D) funding are mostly used in the biotechnology industry. The innovation process in this sector is extremely complicated, and a variety of interactions between various types of entities play a critical role in the advancement of biotechnology (Patra & Muchie, 2017). For instance, there are various types of intricate connections between large corporates, emerging biotechnology companies, government research institutions, and universities. Collaboration between universities and venture capital is crucial for the effective commercialization of innovations. In addition to legislation, regulations pertaining to patents, national health systems, intellectual property rights, and customer demand all have a significant impact on the process of innovation in this industry (Patra & Muchie, 2017).

In recent years, the focus of research on innovation and the development of new products has shifted from a technology-versus-customer duality to an interaction-based strategy. This perspective holds that successful inventions result from interactions between players, usually manufacturers and consumers (Renko et al., 2019).

2.2.2 Key factors contributing to innovation: National System of Innovation (NSI)

Biotechnology innovations are managed through the National System of Innovation (NSI) in South Africa. The system of innovation functions at different levels. In terms of legislation, funding, performance in R&D, innovation, and evaluation, the government is the only player. At various phases, public R&D funding is channelled through the different levels. (Patra & Muchie, 2017).

The NSI method lays a lot of focus on institutions and structures, especially the complex webs of cooperation, exchange of ideas, and feedback among different institutional players. The idea highlights how innovation processes are non-linear and contextually intertwined. The fact that it prioritizes structure over agency, however, results in a poor comprehension of the micro foundations of innovation dynamics and is one of its main drawbacks. The concept has been called into doubt because the research currently in publication provides very little information about the factors that influence NSI change and the underlying processes that underpin the evolution and expansion of NSIs over time (Autio et al., 2014).

Another drawback of the concept is that most of the research relies on a rather restricted definition of innovation, with a primary emphasis on patentable innovations in technology. Additionally, the element of entrepreneurship has been disregarded in the concept of the innovation system.

Entrepreneurship adopts a broad definition of innovation, encompassing both formal and informal intellectual property, services, and processes, in contrast to the NSI literature. The literature on entrepreneurship has a strong emphasis on individual agency, showing that people and entrepreneurial teams are essential to identifying, evaluating, and seizing possibilities for entrepreneurial action. This means that the literature on entrepreneurship portrays a non-linear bottom-up approach by the entrepreneurs, in contrast to the NSI literature's mostly top-down emphasis (Autio et al., 2014).

One of the gaps identified in the literature on entrepreneurship is the narrow scope on the individual, the people, and the resultant business with little consideration paid to how context influences behaviour, decisions, and performance of each venture. This is a significant omission because it is known that all human behaviour takes place in contexts. The context dictates what people and groups observe, what judgments they are inclined to make, and how those decisions materialize. Institutional, industrial, market, organizational, ownership, and governance elements are among the context-influencing factors for entrepreneurial action that have been identified (Autio et al., 2014).

2.3 THE BIOTECHNOLOGY INDUSTRY: GLOBAL PERSPECTIVE

Biotechnology is utilized in a broad range of disciplines, including drug discovery, manufacturing of biologics, research on plants and animals, and medical diagnostics and devices. It is one of the world's fastest-growing industries. In spite of the COVID-19 outbreak, the market is currently worth USD 550 billion globally and is projected to reach USD 727 billion by 2025, with anti-diabetics, anti-rheumatism, and oncology as the top three segments (Howard et al., 2021). In addition, the coronavirus highlighted the importance of the biotechnology industry.

Despite the fact that the market size of the industry and output have remained relatively stable, its impact on the public's perception of new drug development and vaccines for COVID-19 and future pandemics has been outweighed (Howard et al., 2021).

The industry is primarily centred in high-income countries and has been growing since the 1980s. The majority of investments in biotechnology are made by the United States and EU member states, with developing countries accounting for less than 5% of global investments (Martin et al., 2021).

2.3.1 Biotechnology market in Europe

In Europe benefits from the industry contribute towards the growth of the economy and the creation of new jobs, as well as support sustainable development, public health, and environmental protection. The UK has been conducting significant research and investing in drug development using biotechnological methods based on genetic coding and similar techniques. In England alone, the bio sciences sector is estimated to employ about 183 000 people (Martin et al., 2021).

Below is a graphical representation of global research in biotechnology.

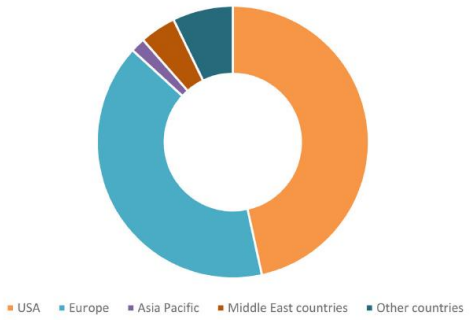


Figure 1: Biotechnology Research Globally
(Martin, Vicente, & Dundar, 2021)

According to reports, in previous years the United States (US) spent 20.5 billion USD on R&D research in the field of biotechnology, while Europe spent 7.6 billion USD (Martin et al., 2021). This makes Europe the second biggest market for biotechnology in the world.

2.3.2 Biotechnology market in the USA

The United States is a global leader in biotechnology. The US government has made record-breaking investments and provided support to the biotechnology industry since 2014. The USA, Canada, and Europe account for 97% of bio-industrial income and 96% of employment (Martin et al., 2021).

The success of the industry in the country was driven by two main aspects. The first one being a strong science push, based on a solid research foundation that had been built. Secondly, the private sector realized the technological and commercial potential of this science or technology push quite early (Moodley, 2008). Entrepreneurs were prepared to take a risk in commercializing biotechnology products, and private investors were willing to take a risk by investing private funds in new ventures.

2.3.3 Biotechnology market in India

India has a market share of roughly 3% in the global biotech industry, placing it among the top 12 nations globally. Additionally, India leads the global market for the supply of medicinal vaccination. More than 2,700 biotech firms make up India's biotech industry, which is predicted to rise to 10,000 companies by 2024. In India, there are more than 2,500 biotechnology start-ups. The industry's market worth in 2019 was 64 billion dollars, and it is expected to reach 150 billion dollars in 2024-2025 (Martin et al., 2021).

India, which has the second-largest population globally, has acknowledged the biotechnology industry as one of the vital economic sectors, and the government has included biotechnology into several of its programs. The country is a pioneer in biotechnology research for agricultural production and environmental protection. The Indian government has been progressively increasing its annual investment in biotechnology (Martin et al.,2021).

As is the case in South Africa, the government in India frequently leads early-stage investment instead than private investors. Later-stage investment for Indian biotech businesses is primarily provided by private equity and venture capital funds. Biotech start-ups in India have become more vulnerable in the past few years due to the decline in early-stage investment. The fundamental reason for this is that investors are switching to later-stage investment strategies due to the absence of private resources to engage in new and riskier firms (Uctu & Eksteen, 2022).

2.1 THE BIOTECHNOLOGY INDUSTRY: AFRICA PERSPECTIVE

Africa has a multitude of natural resources with the ability to fuel economic growth and social development, including land, minerals, biological diversity etc., however they are unevenly distributed. Environmental hazards like droughts and floods, whose frequency and severity are projected to rise due to climate change, pose a threat to the economies and population of Africa (Makinde et al., 2009).

Despite numerous efforts, considerable barriers prevent African economies from expanding their level of innovation and development. Insufficient and ineffective R&D funding is the main issue. Out of all the African nations, the most efficient are South Africa, Tunisia, which launched its first National Innovation System ten years ago, and Mauritius, which is also nearing the efficiency frontier (Dobrzański et al., 2021).

In biotechnology, vaccine manufacturing emerges as a prominent area of discussion. For example, when COVID-19 vaccines were approved for emergency use in November 2020, they were regarded as the most sought-after medical interventions globally. Before the safety and

effectiveness of these vaccines was established, high-income countries took advantage of their financial capacity and entered into advanced market agreements with multiple pharmaceutical companies, while the adoption of COVID-19 vaccinations in Africa fell behind those of other continents in 2021 (Kana et al., 2023).

The lack of funding, the departure of skilled technical personnel, the sluggish growth of the biotechnology industry, the inadequate infrastructure for protecting intellectual property rights, the government's lack of political action in advancing the technology, and the problem of public acceptance brought on by activism are the issues facing biotechnology on the continent. The present state of a national biosafety framework development in Africa demonstrates the lag in the creation of a governance capacity for biotechnology. Only 16 of the 53 member countries that make up the African Union have regulations, policies, or guidelines pertaining to recent advances in biotechnology. Only three countries, Burkina Faso, Egypt, and South Africa, have expertise in evaluating applications for the commercialization of biotechnology crops (Makinde et al., 2009).

Additionally, Africa continues to lag behind the rest of the globe in terms of generating new scientific knowledge (Sammut, 2021). Despite making up about 16% of the world's population, the continent produces fewer than 1% of all research worldwide, according to World Bank estimates (World Bank Group, 2016).

A key takeaway from the evaluation of Africa's position in the global economy is that the continent needs to prioritize developing its own problem-solving capabilities. All of the issues listed above can be resolved through the application of science, technology, and innovation, particularly biotechnology (Makinde et al., 2009).

2.4 THE BIOTECHNOLOGY INDUSTRY: SOUTH AFRICAN PERSPECTIVE

2.4.1 Government policies and initiatives promoting innovation in biotechnology

Traditional biotechnology has been practiced for a very long time in South Africa, although during the apartheid era, government support for biotech research was relatively limited. After the end of apartheid, the democratic government of South Africa actively promoted the growth of a biotechnology sector capable of competing on a global scale. As such, the government launched its National Biotech Strategy (NBS) in 2001, which included a long-term strategy for developing the country's biotechnology industry (Patra & Muchie, 2017). This strategy was relaunched as the Bioeconomy Strategy in 2013.

The bioeconomy strategy is aimed at long-term planning of government for developing and growing the bioeconomy. The South African bioeconomy strategy is a collaborative initiative that involves the various departments in science and innovation, agriculture, health, environment and trade (Hlangwani et al., 2023).

The country's bioeconomy policy framework is characterized as being relatively incoherent in comparison to the bioeconomy-strategy. This has been linked to a lack of a comprehensive policy strategy, while having certain policy aspects on the bioeconomy. Nevertheless, efforts are currently being made to strengthen the ability of central actors to make policy decisions and modify the regulatory framework to accommodate the expected modifications (Hlangwani et al., 2023).

Furthermore, in line with the sector plan, the National Advisory Council on Innovation (NACI) presented a means for monitoring the bioeconomy's development (NACI, 2019). Recently, the government of South Africa has become more actively involved in international bio-innovative alliances. In order to do this, South Africa has set up regional initiatives like the Southern Africa Innovation Support Program and the Southern Africa Network for Biosciences (SANBio) with funding from abroad (Hlangwani et al., 2023).

In contrast to affluent nations such as Finland, most developing countries do not have a holistic approach to bioeconomy and development. This is demonstrated by the difficulties in implementing innovation projects and a regional bioeconomy policy that is well defined. As a result of this limitation, the DSI established the 2020-2025 TIA Strategic Plan to assist with the execution of the District Development Model, which includes information and technology stations that are distributed regionally, and tools to assist in decision support (TIA, 2022).

2.4.2 Overview of the biotechnology landscape in South Africa

The government has established several regional innovation hubs and implemented measures to encourage transnational collaborations that can boost the domestic growth of biotech firms since implementing the biotech policy in 2001. This approach seeks to capitalize on the excellent research being done at universities and research institutions, but it is somewhat constrained by the lack of entrepreneurial mindset among South African researchers because of the expenses involved in securing international patents, among other reasons. Even though the commercial sector is still in its infancy, start-ups are emerging from universities and established businesses. These constitute a critical source of innovation for future commercialization, given that the

difficulties plaguing South Africa's nascent biotechnology industry can be resolved (Cloete et al., 2006).

For several years, South Africa's political isolation from the outside world caused it to retreat inward and develop its own skills in science and technology. The mining, textile, and military industries were the main sectors that profited from this strategy. Conversely, biotechnology was not regarded as being critical to the country's survival and independence. South Africa's political landscape was substantially transformed in 1994, and a strong biotechnology sector is now seen to have the power to favourably impact South Africa's economic and social development (Cloete et al., 2006).

In South Africa, the biotechnology ecosystem is made up of government, enablers such as research institutions, incubators, business institutions, non-governmental organizations, universities, public and private funding institutions, and biotechnology firms (Uctu & Eksteen, 2022).

Funding for early-stage biotechnology entrepreneurs is significantly led by the government through the Medical Research Council (MRC), the Technological Innovation Agency (TIA), the Industrial Development Corporation (IDC), and the Support Programme for Industrial Innovation (SPII), a programme of the Department of Trade, Industry, and Competition (Uctu & Eksteen, 2022).

2.4.3 The Biotechnology Market

In 2015, the biotechnology market in South Africa was valued at $1.18 billion. The market's overall value was anticipated to be over USD 1.76 billion in 2020. The medical and health care area is where most revenue is generated. This segment’s revenues were roughly USD 0.79 billion in 2015. The biotechnology market was expected to increase steadily at a rate of 0.8 percent from 2015 to 2020, as per figure 2 below (Patra & Muchie, 2017).

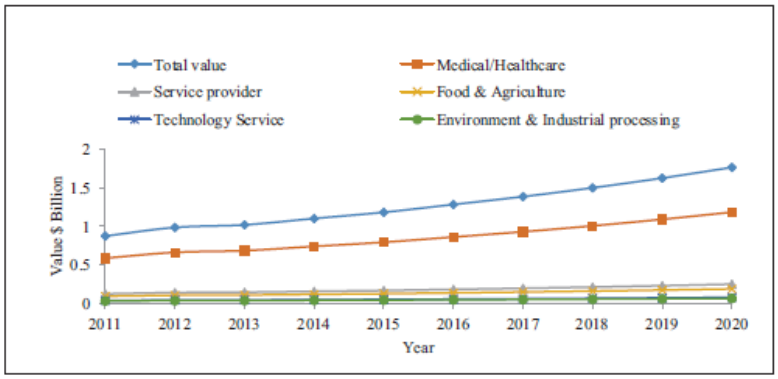


Figure 2: Biotechnology Market in South Africa (Patra & Muchie, 2017)

Based on the above, the South African biotechnology market has been growing steadily. From 2015 to 2020, the market's overall value was expected to increase from $1.18 billion to over $1.76 billion. This indicates a positive trend and potential opportunities for entrepreneurs in the biotechnology sector.

The anticipated growth rate for the biotechnology market in South Africa from 2015 to 2020 was 0.8 percent. While this growth rate may seem relatively low, it still indicates a positive trajectory and suggests a stable market environment for biotechnology entrepreneurs.

2.4.4 Barriers to entry in the Biotechnology Industry

Capital

Biotechnology is a capital-intensive industry, particularly for early-stage companies, of which several years of research and development are required, from invention to commercialization. One of the issues in the field is the dependency on finance from the concept stage to regulatory approval, clinical studies, and commercialisation. The biotech product cycle takes 10 to 12 years and involves capital investments in the range of USD 650 million to USD 1.8 billion. As such, the start-up capital for new biotechnology enterprises could run into the millions of dollars (Uctu & Eksteen, 2022). The industry is perceived as underdeveloped, fragmented, and fractured due to insufficient funds, including startup investment, and the absence of a dedicated organization to coordinate activities. Additionally, biotechnology research is expensive, as proper facilities and reagents are required. Attracting investors is extremely challenging due to the significant costs and risks. The risks involved with biotechnology projects are numerous, and hefty costs are often unjustified if the technology is not accepted during one of the validation stages (Zemlickiene & Turskis, 2020).

Human Capital

When it comes to publications and international partnerships, South Africa boasts a remarkable pool of researchers. However, the government ought to consider investing more in younger scientists rather than a small number of highly recognized project leaders. (Uctu & Eksteen, 2022).

In terms of COVID detection, South African scientists were pioneering, but there was no systematic attempt at capitalizing on it. Opportunities exist in the industry, technical and scientific skills are prevalent, however commercialization and scaling-up skills are lacking. Scaling up is a significant problem, especially when it comes to large-scale trials and developing the foundational

skills needed for manufacturing and producing scalable goods and services (Uctu & Eksteen, 2022).

Regulatory Environment

The ecosystem has become heavily dependent on government and has grown quite politicized. To counteract this, the government should eliminate corruption, remove links with networks that are unsustainable, and transform the environment to be less politicized. The industry is also heavily reliant on imports to local research and development and manufacturing (Uctu & Eksteen, 2022).

Uctu and Eksteen (2022) assert that biotechnology start-ups believe there is currently no supportive ecosystem for the biotechnology industry in the country. This lack of support hampers innovation since innovation is not solely a product, but rather an environment.

In addition, the government is perceived as hindering venture creation and development by failing to commit to sustainable procurement prices. This forces biotech businesses to compete in global markets, putting them at a disadvantage compared to domestic markets (Uctu & Eksteen, 2022).

South African policymakers made the decision to switch their attention from a regional to a national biotech approach, led by the Technology Innovation Agency (TIA). Due to these developments, a lack of funds, and other political factors, the TIA changed its focus to investing solely in "low hanging fruits" or businesses nearing product commercialization. Certain individuals considered it an unwise policy decision, emphasizing that when funding biotechnology companies, it is crucial to recognize that sector expansion relies on investments in early-stage research. Many businesses struggle to overcome the "valley of death" where financial constraints hinder their progress. Furthermore, the National System of Innovation (NSI) is heavily reliant on the network, which raises the question of how willing the system is to uncover new novelties and give opportunities to young innovators who would pursue their ideas with passion (Uctu & Eksteen, 2022).

The market in South Africa is comparatively limited in size to sustain viable start-ups over the long term.; in order for products to become more sustainable, they must be sold in outside markets. For example, South Africa has lagged behind in the vaccination race due to the pace with which vaccines are developed, access to research funding, the level of preparedness of local vaccine manufacturers, and the difficulty in registering new pharmaceutical products in South Africa (Uctu & Eksteen, 2022).

The requirement for extensive safety testing, multistage clinical research, and regulatory validation places significant constraints on the development of biotechnology in the areas of human and animal health (Zemlickiene & Turskis, 2020). The biotech regulatory authority, i.e.,

the South African Health Products Regulatory Authority (SAHPRA) has proven to be inefficient, and the government has been slow to action regulatory approvals.

Intellectual Property

The lengthened period for product development is caused by bureaucratic and slow biological procedures. The typical time frame for product development is at least seven to ten years and, at most, twelve to fifteen years. Additionally, the biotechnology patenting process has a substantial impact on the development process, the processes prior to the innovation reaching the market often consume a significant part of the useful patent protection period (Zemlickiene & Turskis, 2020).

Biotechnology ventures are hampered in their early and middle stages by the patenting procedure. It competes for resources such as time and finances that could be allocated towards further product development (Zemlickiene & Turskis, 2020).

2.5 THE ROLE OF MARKET, ENTREPRENEURIAL, AND TECHNOLOGICAL CAPABILITIES

2.5.1 Market Capabilities

Extensive research on market orientation from a behavioural market perspective has consistently revealed a positive correlation between market orientation and innovation. A company launches more novel products and fewer imitated offerings when it places more of a focus on customer orientation. In the context of small businesses, market orientation determines the success of new products. Consequently, it can be implied that market orientation within a biotechnology company is expected to exhibit a positive correlation with product innovation (Renko et al., 2019).

2.5.2 Entrepreneurial Capabilities

Entrepreneurial firms, compared to more cautious ones, innovate aggressively and take major risks in their product-market strategy. Firms that innovate are considerably more willing to undertake risks and pursue assertive market leadership compared to those that do not innovate. Entrepreneurial orientation is found to have a positive influence on ground-breaking innovations in the literature. Findings imply that business owners that adopt a risk-taking and competitively proactive perspective develop novel products that are highly distinctive (Renko et al., 2019).

2.5.3 Technological Capabilities

A crucial element of a company's knowledge foundation and the bedrock for sustaining a long-term competitive edge lies in its technological capabilities. Technological competence, comprising technical expertise, confidential information, patents, know-how derived from research and development, and other intellectual property, is the driving force behind a company's innovation.

Substantial investments in patents and research and development are expected to enhance a firm's capacity for product innovation and attract investor interest. Furthermore, in a technology-intensive sector such as modern biotechnology, a firm with a robust technical foundation is likely to reinforce the anticipated positive outcomes of market orientation. It is essential to note that market-derived concepts in biotechnology may not transform into viable products unless they undergo rigorous research and development processes and are safeguarded through proprietary procedures (Renko et al., 2019).

2.6 SOURCES OF INNOVATION: TECHNOLOGY PUSH AND DEMAND-PULL

The review of literature explores how the two sources of innovation: science push and market-pull can be leverage in order to commercialise successful innovations. Technology push perspectives highlighted the key science and technology competencies required in developing technological innovations. Whereas, the demand-pull perspective identified market features, that affects innovation performance (Di Stefano et al., 2012).

A biotechnology start-up requires three pillars to be successful: effective management, which includes key personnel, infrastructure, business support services; access to cutting-edge technology that results in the development of new products, which covers a solid science base and entrepreneurship culture and sufficient capital to sustain the business (Uctu & Eksteen, 2022).

The biotechnology industry is promising and has produced some ground-breaking research, but because the ecosystem is not particularly entrepreneurial, not much of this research gets pushed into the market or turned into commercial products. Notwithstanding the system's fragmentation, there are important factors that could support a robust ecosystem for innovation, including top-tier research and development facilities, a diverse biodiversity, disease profiles, and dedication from government. However, the pivotal factor lies in the commitment of the South African Government Treasury and the Department of Trade, Industry, and Competition to fully endorse the industry from a governmental perspective, potentially through guaranteed off-take agreements and long-term contracts (Uctu & Eksteen, 2022).

According to a study conducted by Zemlickiene and Turskis (2020) on assessing the commercial potential of biotechnology, a number of elements were evaluated. In terms of these elements, technology features ranked the most important, the second ranking was the value for the consumer, market situation ranked third, technical competencies fourth, financial environment fifth, legal environment sixth, internal policies seventh, inventors' profile eighth and lastly in the ninth position is competitive environment. The evaluation demonstrates that in biotechnology the technology push innovation strategy is the most important based on the technology feature ranking in the first position, this element includes the novelty of the technology and product compatibility with existing products in the market. The market pull strategy is seen in the third ranking on market situation, where an analysis of the target market, consumer needs and the state of readiness of the market for the product are considered. Essentially, the commercial potential of biotechnologies is mainly influenced by the top two rankings as indicated above.

Patents are useful indicators for assessing an entity's technological capabilities for commercially generated technology innovations (Patra & Muchie, 2017). However, a patent can only be deemed valuable once there is a product that can be taken to market. Biotechnology start-ups may face challenges in future if they fail to focus on commercial market demands and instead concentrate solely on the innovation. Formal intellectual property, such as patents and trademarks, can offer the credibility required to begin discussions and be taken into consideration by clients and investors. In addition, first mover advantage can be gained by retaining technical knowledge and know-how within a start-up through informal IP or keeping a trade secret (Hellstrom et al., 2019). This is one of the technology push drivers used by biotechnology players to leverage the strategy for competitive advantage.

An integrated design approach is necessary for successful innovation; this includes integrating enterprise design, new product development, and the conception and execution of novel technologies. Strong collaboration and concept management are required for this type of integrated design effort and they should be backed by effective knowledge management strategies and technologies. The planning phase becomes crucial in the innovation process if the aim is to help expand the business and boost its competitiveness (Du Preez & Louw, 2014).

According to a study done on competition and innovation by OECD, a different dynamic has been brought to the fore. The study examined the relationship between competition and innovation. The study identified a gap on the general belief that competition stimulates innovation, leading to economic growth, whereas the exact nature of this relationship in a market economy remains unclear (Pabón & Capobianco, 2023).

The study explores how competition can drive innovation and how innovation, in turn, affects competition. It suggests that while competition may promote innovation, the relationship is complex and impacted by several elements, such as the competitiveness of the market and the potential for innovation to be appropriated. Furthermore, innovation can reshape markets and create new opportunities, while being driven by a multitude of factors beyond competition alone (Pabón & Capobianco, 2023).

2.7 RESEARCH GAPS

The empirical research landscape in biotechnology entrepreneurship has primarily focused on developed countries, where statistics from the industry have been extensively monitored over years (Alagbaoso et al., 2015). Studies in these contexts have delved into innovation competitiveness and its impact on entrepreneurial dynamics and market competitiveness. However, research on biotechnology entrepreneurship in developing countries remains nascent due to limited accessibility and monitoring of industry statistics (Alagbaoso et al., 2015). In South Africa, literature predominantly addresses governmental support and sector development, with less emphasis on entrepreneurship aspects within biotechnology.

Despite the significance of technology entrepreneurship, including biotechnology, the field remains underexplored, with only a handful of scholars publishing in prominent journals (Bailetti, 2012).

In contrast, the "big three" infectious diseases—tuberculosis, HIV/AIDS, and malaria, as recognized by the World Health Organization (WHO)—are major health challenges in South Africa and Africa overall, highlighting the critical need for biotechnological solutions. However, the relatively low prevalence of these diseases in developed countries discourages major pharmaceutical and biotechnology firms from investing in treatments for these diseases (Donninger, 2006).

This dilemma prompts the question of how developing countries like South Africa can foster an environment conducive to entrepreneurship in the biotechnology sector, thereby addressing the healthcare needs not only locally but also for the broader African continent.

2.8 ANALYTICAL FRAMEWORK

2.8.1 Theoretical Framework

2.8.1.1 Schumpeterian Theory

This study is underpinned by the Schumpeterian theory. According to Schumpeter's theory, innovation is a crucial component that drives economic dynamism and competitiveness. His insights into the role of entrepreneurs in capitalizing on scientific and inventive discoveries to create new avenues for investment, expansion, and job creation are particularly relevant in the context of today's knowledge-based economy (Śledzik, 2013).

In Schumpeter's early work (1934), he emphasized the pivotal role of entrepreneurial businesses as the main drivers of industry change and innovation. Entrepreneurs were viewed as the primary innovators, driving economic growth through their creative and disruptive ventures (Śledzik, 2013). This perspective highlights the importance of individual initiative and ingenuity in fostering innovation within the economy.

However, Schumpeter in his later work (1942) recognized the emergence of large, science-based entrepreneurial businesses as significant contributors to innovation and economic growth. In this revised perspective, the focus shifted from individual entrepreneurs to collaborative efforts involving diverse players within the innovation ecosystem (Jeon, Hong, Yang, & Ohm, 2016). This shift reflects the increasing complexity of technological advancements and the interdependence of various capabilities in driving innovation forward.

In today's knowledge-based economy, rapid technological advancement is a key driver of competitiveness. As a result, more and more diverse players work together to generate innovation instead of relying solely on the capabilities of specific people. This necessitates cognitive competencies that improve diffusion of innovation and consequently the understanding of innovation, which leads to entrepreneurship (Śledzik, 2013).

Additionally, according to Arrow's theory increased competition has a positive impact on innovation efforts when rivalry is low. However, Schumpeter argues that once competition reaches a significant level, it diminishes incentives for innovation (Pabón & Capobianco, 2023).

In industries with similar technological levels, increased competition stimulates innovation which suggests that competition boosts incentives for innovation. In contrast, in fields with varying technology levels, the Schumpeterian effect comes into play, where limited competition leads to innovation incentives arising from increased profits. In such cases, firms lagging in technology

have minimal motivation to innovate, as the rewards for catching up with the industry leader are limited (Pabón & Capobianco, 2023).

Schumpeter's theory underscores the importance of innovation in driving economic competitiveness and highlights the evolving role of entrepreneurs in harnessing technological advancements to create value.

2.8.1.2 Innovation Management Framework

The framework primarily emphasizes road mapping for strategizing and executing innovation within a collaborative implementation setting (Du Preez & Louw, 2014).

The framework features innovation processes that outline the management and phases from the ideation stage to technology commercialization. The models of the innovation process have evolved across six generations, progressing from simple linear models to more complex interactive models, as illustrated in Table 1 below.

Table 1: Innovation Models of the Innovation Management Framework (Du Preez & Louw, 2014)

Model Generation Characteristic	Generation	Characteristic
Technology push	First	Simple linear sequential process with a focus on science and research and development.
Market pull	Second	The process is linear and methodical, with a focus on marketing, and new R&D concepts are derived from the market.
Coupling model	Third	Emphasis is placed on merging R&D and marketing while also acknowledging the interaction and feedback loops between various elements.
Interactive model	Fourth	Push-pull model combinations, internal integration, and a focus on external connections.
Network model	Fifth	This model places emphasis on acquiring knowledge, creating external connections, integrating systems, and extensive networking
Open Innovation	Sixth	To further innovative technology development, internal and external concepts and internal and external routes to market can be merged.

Given the multitude of variables impacting innovation and design processes, it is not feasible for a single framework to provide a universally applicable solution. Presented below is a summary of the innovation process models documented in the literature, as suggested by Du Preez & Louw (2014):

- Most models of the innovation process include the following stages: (i) idea generation and identification; (ii) concept development, (iii) concept validation; (iv) technology development; and (v) implementation.
- Market pull, technology push, or a combination of both can lead to innovation.
- Integration across the various activities within the innovation process is crucial and frequently acts as a differentiator.
- The most recent (open) innovation process models encourage a network strategy where innovation is targeted both inside and externally.
- The majority of the models overlook the exploitation of new innovations in the market. Exploitation is the sole avenue for achieving competitiveness and financial sustainability, and therefore, it should be incorporated into the framework.

2.8.1.3 Integrated Innovation Management Framework

Technology push, market pull, and organizational approach are just a few of the innovation theories that can be found in the literature. The lack of integration and relevance of each of these theories to the current competitive climate has drawn criticism (Khilji et al., 2006). Based on this, an integrated perspective on innovation has been formulated, consolidating the variables from previous models.

Given the difficulties in managing the lengthy development cycle and extensive collaborative activities of the industry, an integrated framework is particularly pertinent to biotechnology enterprises. The literature findings revealed that biotech entrepreneurs are inadequately equipped to navigate their companies through the numerous changes necessary along the product life cycle. This is attributed to their reliance on a technology-push approach and a lack of comprehension of integrated innovation (Du Preez & Louw, 2014). Entrepreneurs also have inadequate commercialization capabilities necessary to introduce products to markets, leading to avoidable delays and productivity setbacks. The innovations models highlighted above, failed to address these challenges. Utilizing the integrated innovation management framework in biotechnology

entrepreneurship underscores the importance of integrating market-oriented mechanisms, establishing and leveraging suitable organizational capabilities, fostering successful collaborations, and cultivating parallel interactions as essential elements within a comprehensive strategy to enhance the success and efficiency of biotech firms (Khilji et al., 2006).

The initial innovation models from the 1950s and 1960s, technology push and market pull, envisioned a unitary series of phases in product development. In contrast to the latter, which considered the market as the main origin of new ideas and relegated R&D to a purely reactive role, the former was only concerned with technology and paid no attention to market considerations (Khilji et al., 2006).

As the intricacies of the innovation process became evident, an organizational perspective emerged, presenting innovation as a continuous sequence of events and emphasizing the importance of adaptability within the business landscape. The study aimed to pinpoint significant structural elements within organizations, including concepts such as centralization, formalization, size, and organizational objectives. (Khilji et al., 2006).

Moreover, during the late 1980s, an increasing amount of research advocated for an integrated perspective, which represented the fusion of both technology-driven and structural components within the organization. This perspective perceives the innovation process as the interplay of the organization's structural functions aimed at knowledge generation. Through external connections, knowledge is disseminated from R&D to manufacturing, marketing, and service departments. The initial phase of the innovation process is determined by three primary variables: (i) organizational capabilities, (ii) scientific and technological developments, and (iii) the marketplace (Khilji et al., 2006). Van de Ven and Rogers (1988) and Pettigrew (1985) are primarily responsible for the inception of this new body of work.

The components of Rothwell's (1994) integrated perspective include a complicated network of internal and external organizational links that connect the firm's internal activities with the larger scientific and technological community as well as the market. This viewpoint appears to be applicable to the biotech industry due to its use of tacit knowledge and interdependence with external agencies, which compel enterprises to draw on organizational, technological and scientific, and market resources in order to innovate (Khilji et al., 2006). The integrated management framework was established with an interconnected approach in mind led by Rothwell (1994), Pettigrew (1985), and Van de Ven and Rogers (1988).

The biotech industry's innovation process from a concept to a marketable product is multifaceted and involves extensive collaborative action. Funding is essential to complete different phases of

R&D, and the capability to expedite development is a crucial factor in shaping a company's competitiveness. It is therefore against this background that the integrated model contends that the sequential stage model is inappropriate because it does not emphasize how different functions interact with one another or take into account how important the market is in identifying market niches for the development of novel products (Khilji et al., 2006).

As per Rothwell (1994), this model portrays a complex network of intra- and interorganizational connections, comprising parallel, interconnected, and interdependent stages that advocate for an integrated approach to innovation management. Unlike the conventional technology push model commonly adopted by biotechnology entrepreneurs, this innovation model is designed to assist biotech companies in comprehending the effective development of products and inventions along the pipeline, thereby addressing organizational and management obstacles (Khilji et al., 2006).

The theoretical framework focuses on the evolution of innovation models and the necessity for an integrated approach to address the challenges faced by biotechnology companies. Initially, innovation models were characterized by linear processes, such as technology push and market pull, which failed to account for the intricacies of innovation development. Subsequent models emphasized the importance of institutional factors and external linkages in driving innovation.

The integrated innovation management framework synthesizes these models, acknowledging the multifaceted nature of innovation in biotechnology. It emphasizes the interaction between organizational capabilities, technological advancements, and market dynamics. Unlike traditional models, the integrated approach recognizes innovation as a continuous and collaborative process, involving various stakeholders and functions within the organization.

In summary, the Schumpeterian theory is justified over the innovation management framework for several reasons. The Schumpeterian theory provides a comprehensive framework for understanding innovation dynamics, particularly in entrepreneurial contexts like the biotechnology sector. It provides valuable insights into the role of entrepreneurs, the dynamics of innovation, and the incentives for innovation, aligning closely with the research objectives outlined for this study.

Whereas, the Innovation Management Framework, primarily focuses on structured innovation processes and organizational approaches, the Schumpeterian theory places a strong emphasis on entrepreneurial ventures as the main drivers of industry change and innovation.

2.8.2 Conceptual Framework

The conceptual framework includes two components with biotechnology entrepreneurship as the dependent variable and technology drivers as the independent, as these both influence the competitiveness of biotechnology innovations (Figure 3).

Biotechnology Entrepreneurship as a dependent variable represents the outcome or result of entrepreneurial activities within the biotechnology sector. It encompasses the establishment, growth, and performance of biotechnology ventures, including the development and commercialization of innovative products, processes, and services. Biotechnology entrepreneurship serves as the focal point of the study, reflecting Schumpeter's emphasis on innovation as a crucial driver of economic dynamism and competitiveness.

Technology Drivers as an independent variable comprises the diverse factors and mechanisms that influence technological innovation within the biotechnology industry. These drivers have been categorized into three: technological, entrepreneurial and market. may include scientific research and discoveries, technological infrastructure, regulatory. Understanding the influence of these drivers is essential for comprehensively analysing the innovation dynamics in biotechnology entrepreneurship.

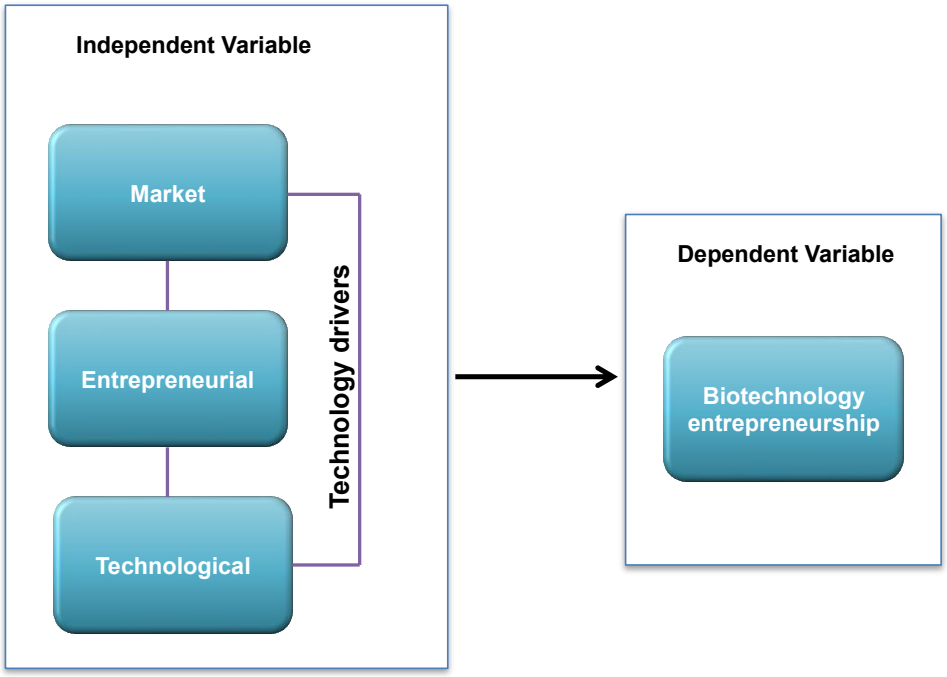


Figure 3: Conceptual Framework

In the following sub-sections, the key concepts are defined in the context of biotechnology entrepreneurship.

Independent Variable: Technology drivers

Technological capabilities refer to an organization's knowledge, skills, and resources related to technology and its application. It includes factors such as R&D expertise, access to advanced technologies, infrastructure, and the ability to integrate technology into products and processes effectively. A significant part of a company's knowledge base is its technological capacity (Renko, Carsrud, & Brannback, 2019). Businesses with strong technological capabilities can leverage advanced tools, knowledge, and expertise to develop novel products and improve existing products.

Entrepreneurial orientation refers to the strategic orientations and behaviours of firms that embody an entrepreneurial mindset. The underlying dimensions of entrepreneurship include innovativeness, reactiveness, competitive aggressiveness, risk-taking, and autonomy (Bii & Onyango, 2018). Entrepreneurial orientation is an environmental management capability that allows businesses to take proactive steps to alter the competitive landscape. This involves generating, engaging, and reacting to technological knowledge instead of responding to market intelligence (Renko, Carsrud, & Brannback, 2019). Firms with a higher level of entrepreneurial orientation, characterized by their innovativeness, risk-taking, proactiveness, autonomy, and competitive aggressiveness, are more likely to engage in product innovation activities and introduce new and improved products to the market.

Studies indicate that placing a greater emphasis on customer orientation, a component of market orientation, boosts the introduction of new products while reducing the number of imitative products launched by a company (Renko, Carsrud, & Brannback, 2019). Market dynamics determine the success of a viable biotechnology business. This is more pertinent in the biotechnology industry, particularly because scientists or inventors tend to focus on creating a new technology without necessarily taking market demand or commercial viability into account, which ultimately leads to innovations not taking off in the market or high failure rates.

The independent variable is defined in table 2 below, its measures and linkages to the dependent variable.

Table 2: Construct, Interpretation & Measure

Construct	Interpretation	Measures	References

Technological capabilities	Understanding & capitalizing on the potential impact of emerging technologies and trends on the business capabilities and preparing for future technological advancements.	Technological resources and skills, identifying areas for improvement or investment, and aligning the capabilities with the firm's strategic goals.	(Khilji, Mroczkowski, & Bernstein, 2006)
Entrepreneurial orientation	Behaviours of firms that embody an entrepreneurial mindset	Innovativeness, proactiveness & risk-taking	(Renko, Carsrud, & Brannback, 2019)
Market dynamics	Innovations successfully taken to market or successful deployment of technologies.	Market research & intelligence, regulatory requirements met, technology readiness level, value for the customer, competitive landscape.	(Du Preez & Louw, 2014)

2.9 CONCLUSION

The literature review concludes that innovation in the biotechnology sector is a multifaceted process influenced by factors such as market capabilities, entrepreneurial orientation, and technological advancements. In South Africa, the National System of Innovation (NSI) plays a pivotal role, but its limitations, including a narrow definition of innovation, pose challenges. While the global perspective highlights rapid growth, there are disparities between high-income and developing countries. South Africa has made progress in promoting innovation but faces barriers like capital constraints and regulatory challenges. Market, entrepreneurial, and technological capabilities drive innovation in biotechnology entrepreneurship. Further research is needed, particularly in understanding the dynamics in South Africa, to foster a conducive environment for biotechnology innovation and entrepreneurship.

CHAPTER 3: RESEARCH METHODOLOGY

3.1. INTRODUCTION

This section focuses on the research methodology of the research study which aims to investigate the drivers influencing innovation in biotechnology entrepreneurship and evaluate the relevance and effectiveness of technology push and demand-pull models of biotechnology entrepreneurship in Gauteng, South Africa. This chapter discusses the research's procedure and methodology, as well as the target population and sample selection technique. The chapter goes into additional detail on the methodology used to create the research instrument, the procedure for gathering data, analysis, and ethical considerations.

3.2. RESEARCH APPROACH

A qualitative research approach was used for this study because it aims to investigate and gather insights on the factors influencing innovation and commercialization in the biotechnology entrepreneurship sector. Qualitative research allowed for an in-depth understanding of information, detailed insights into the experiences and factors that influence innovation and entrepreneurship.

Through qualitative research, underlying reasons, motivations, and complexities associated with the various aspects of the research questions were uncovered. Additionally, qualitative research allowed for flexibility in data collection and analysis, allowing the researcher to adapt their approach as new insights emerged (Creswell, 2014).

3.3. RESEARCH PARADIGM

A constructivist research paradigm has been chosen for this paper. This paradigm aligns well with this study because it emphasizes the importance of understanding the subjective realities and experiences of individuals involved in the biotechnology entrepreneurship sector. This paradigm acknowledges that knowledge and meaning are constructed through social interactions and interpretations, and that different individuals may have unique perspectives and understandings of concepts (Creswell, 2013).

This paradigm allowed active engagement with participants and co-construction of knowledge through dialogue and iterative processes. This aligns with the aim of understanding the factors

influencing innovation in the biotechnology entrepreneurship sector, as it requires an exploration of the lived experiences, beliefs, and interpretations of entrepreneurs.

3.4. RESEARCH DESIGN

The approach was premised on grounded theory which allowed for the development of a theory grounded in the actual experiences and perspectives of the participants. This approach was particularly beneficial for this study due to its ability to generate theories that are grounded in the data and allow for in-depth exploration of complex phenomena. Grounded Theory is especially useful when researchers aim to develop new theoretical frameworks based on empirical data (Charmaz, 2014), making it a suitable approach for this study.

3.5. SAMPLE, SAMPLING TECHNIQUE AND SAMPLING FRAME

Sample: a sample of 14 participants were selected from Gauteng, specifically the Pretoria and Johannesburg regions.

Sampling technique: a purposive sampling technique was used to identify and select participants who are involved in biotechnology entrepreneurship in Gauteng.

Sampling frame: participants were selected based on their involvement in biotechnology entrepreneurship and innovation within the sector. Participants operating in the agriculture and health biotechnology sectors with innovations in the biopharmaceuticals, agritech, medical devices and diagnostics industries were selected.

Population: The study population comprised of biotechnology entrepreneurs operating in the agriculture and health sectors, based in Gauteng.

3.6. DATA COLLECTION PROCEDURES

The research instrument that was used is an in-depth semi-structured interview: which was conducted with key entrepreneurs operating in the biotechnology sector in Gauteng. Consenting participants allowed the audio recording of the interviews, which were then transcribed for study. The open-ended nature of semi-structured interviews allowed for probing and follow-up questions, enabling a comprehensive understanding of the participants' perspectives and experiences.

The process of data collection involved the following:

A guide for semi-structured interviews with open-ended questions related to the research questions was developed. The guide allowed flexibility for participants to provide detailed responses.

The interview had four main sections, which addressed background questions, followed by Key Drivers Influencing Innovation Competitiveness; Market, Entrepreneurial, and Technological Capabilities Driving Commercialization; Factors Facilitating or Hindering Innovation Models in Biotechnology Entrepreneurship (Appendix A).

A pilot test of the interview guide was conducted with three (3) of participants to ensure clarity and effectiveness. The interview guide was iteratively enhanced after some of the participants interviews as new information and insights were introduced.

Potential participants were identified through The Innovation Hub's BioPark biotechnology incubation programme, which supports the development of biotechnology entrepreneurs. The list of entrepreneurs provided by the incubator was used to contact the entrepreneurs individually wherein the aim of the study was outlined, and their consent requested.

Permission to interview BioPark Business Incubator participants was acquired from the Innovation Hub Management Company (Appendices E and F). Email queries were sent to the participants. Virtual one-on-one interviews were conducted with the participants via MS Teams.

The participant received context regarding the aim of the study and the intended use of the data (Appendix C). The interviewee was informed that video recording of the session would be made in order to transcribe it. Participants were asked questions based on the interview guide. Based on their answers, other questions that weren't in the interview schedule were asked.

The data collecting platform was utilized to record the interviews, which were then transcribed and used for thematic analysis and coding. The voice recordings were not published. Supplementary notes were also taken.

3.7. DATA ANALYSIS

The analytical model that was used is thematic analysis used to transcribe and code the interview data to identify emerging themes and patterns related to the research questions. Thematic analysis has been identified as most suitable for the study because it provides a flexible approach that is applicable to a variety of research questions. Additionally, thematic analysis will provide a holistic perspective in terms of considering the data as a whole rather

than focusing on isolated components. An inductive approach was followed, which means that the themes and patterns emerged directly from the data and were not predefined.

Key tools of grounded theory include theoretical sampling, coding, and constant comparison. In constant comparison, you compare one set of data with another set of data (Sekaran & Bougie, 2016). Constant comparison was also used to compare and contrast the findings across different interviews and observations to identify similarities, differences, and variations in perspectives.

To conduct data analysis for the study, the following data reduction stages were followed:

Data Preparation:

The semi-structured interviews were recorded and transcribed, and supplementary notes were also used. This involved converting the recorded interviews into written text.

Data was anonymized by removing any personally identifiable information to ensure confidentiality.

The transcriptions were organized, and a coding framework was created that aligns with the objectives. These categories included relevant themes that emerged from the interviews.

Initial Coding:

The initial coding process was initiated by assigning relevant codes to specific sections of the text. These codes reflected the key concepts, themes, related to innovation drivers and the effectiveness of technology push and demand pull. During the process of coding, patterns or recurring themes that emerged from the data were identified.

Data Analysis and Synthesis:

Once the initial coding had been completed, the coding scheme was reviewed and refined as necessary. The codes were merged or split as required to capture the nuances of the data.

3.7.1 Reliability and Validity

The reliability of this study is established through several key elements. The research adopts a consistent and systematic approach by conducting virtual one-on-one interviews with semi-structured questions. This standardized method ensures uniformity in data collection procedures across all participants. Additionally, the use of purposive sampling to select biotechnology entrepreneurs involved in specific sectors and industries enhances reliability by targeting individuals with relevant expertise and experiences. Furthermore, the thematic analysis of the

collected data adds to the reliability of the study by providing a structured framework for interpreting and synthesizing the interview findings.

The validity of the study is supported by factors that enhance the credibility of the findings. Credibility assesses whether the research findings accurately reflect the participants' original data and whether their views have been interpreted correctly (Anney, 2014). The use of one-on-one interviews allows for in-depth exploration of participants' perspectives and experiences, contributing to the validity of the data collected. Moreover, the purposive sampling strategy ensures that participants are selected based on their relevance to the research topic, thereby enhancing the internal validity of the study. Furthermore, the thematic analysis of the interview data provides a structured and systematic approach to data interpretation, ensuring that the conclusions drawn are firmly grounded in the empirical evidence. This research maintained its credibility by leveraging the support and guidance from the research committee and an appointed research supervisor.

3.8. LIMITATIONS OF THE STUDY

- The study is limited by the relatively small sample size of 14 participants, which may not capture the full diversity of experiences and perspectives within the biotechnology entrepreneurship sector in Gauteng.
- The study is focused on Gauteng and the findings may not be generalizable to other provinces within South Africa.
- The study exhibits geographical bias as it solely involves participants from Pretoria and Johannesburg, which is not a representation of the entire Gauteng province.
- The use of purposive sampling means the findings of the study are limited to the specific types of biotechnology entrepreneurs selected.
- Limitations in the participants' knowledge or perspective could impact the comprehensiveness of the findings.

3.9. ETHICAL CONSIDERATIONS

The research study complied with the University of the Witwatersrand, Wits Business School ethical research guidelines and ethical clearance was obtained from the Research Ethics Committee.

The Innovation Management Company granted permission for the study to be conducted. Each interview participant provided written consent (see Appendix B) or recorded verbal consent. Every participant was informed about the scope, objective, and outcomes of the study.

All interviewees were informed that if they choose to withdraw from the study at any time, all of the data they provided would be deleted. The transcripts of the interviews were not released. Personal identifiers and participant names were kept private. Confidentiality and anonymity of the participants were preserved.

CHAPTER 4: PRESENTATION OF RESULTS & DISCUSSION

4.1 INTRODUCTION

This segment presents the results of the study. In this section, the results are displayed in the most observable form to enable more understanding of the interview data that was collected. The most vital ideas that arose from the coding process were chosen and then contrasted with the existing literature and quotes from the research participants in view of answering the research queries that were presented at the beginning of the study.

Fourteen (14) one-on-one interviews were conducted with biotechnology entrepreneurs. The participants were spread across the agritech, agroprocessing, biopharmaceuticals, cosmeceuticals, industrial biotech, indigenous knowledge systems, medical devices and diagnostics industries within the biotechnology sector.

The subsequent segments cover the results and discussion of all the findings with respect to the study objectives.

4.2 THEMATIC DATA ANALYSIS

Thematic data analysis is a practice applied to recognise patterns or very important opinions in an unstructured interview data (Fereday & Muir-Cochrone, 2006). Consequently, thematic data analysis involves the identification of linkages within interview data and the emerging ideas turn out to be the categories for qualitative data analysis. Furthermore, thematic data analysis is a qualitative research approach that could be frequently applied through a set of approaches and research questions (Nowell et al., 2017). Thematic data analysis is characteristically applied to verbal information, such as conversation texts. Braun and Clarke (2006) recognised two methodologies to thematic data evaluation known as the inductive and deductive methodologies. An inductive approach entails letting the data to ascertain themes while a deductive approach entails having some predetermined themes the researcher anticipates the data would reveal, established on theory or prevailing knowledge (Braun & Clarke, 2006). In this analysis, the inductive approach was used in which the verbal information in the form of interview texts determined the themes.

4.2.1 The data coding process

This thematic data analysis process used a sample of fourteen (14) research participants that comprised of entrepreneurs in the biotechnology sector in Gauteng. The interview recordings were transcribed into word document texts and then uploaded into NVivo 12 (Qsrinternational.com, 2024). Then each interview record was carefully read, and the most useful testimony was coded into themes using the NVivo 12 programme (Qsrinternational.com, 2024). The fourteen (14) research participants were labelled as P01 to P14 to maintain their privacy as agreed at the start of the study. The coding procedure led to themes that would answer the research questions. In Figure 4, there are four nodes and twelve child nodes that arose from the semi-structured interview data. Table 3 illustrates the importance of the interview questions, the literature review concepts, and also the important ideas from the interview data.

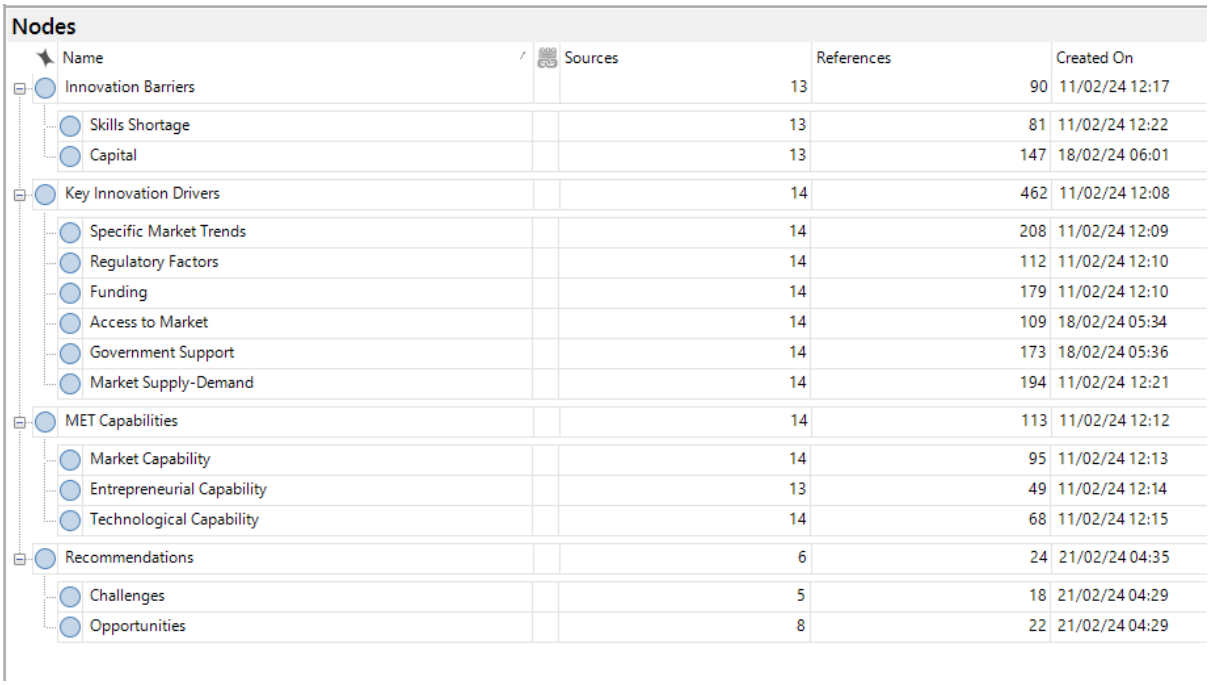
Table 3: Interview questions, literature review concepts, and important themes from the interview

Interview question	**Literature review concepts**	**Important theme**
(1) In your opinion, what are the main factors or drivers that influence innovation competitiveness within the biotechnology entrepreneurship sector?	Innovation in the Biotechnology Sector The Concept of Innovation and its Significance for Entrepreneurship Key Factors Contributing to Innovation: National System of Innovation (NSI)	Access to Market Funding Government Support Regulatory Factors Specific Market Trends
(2) Can you identify any specific market trends or demands that drive innovation competitiveness in this sector?	The Biotechnology Industry: Global Perspective The Biotechnology Industry: South African Perspective	Market Supply-Demand Specific Market Trends
(3) Are there any regulatory or policy factors that have an impact on the innovation competitiveness in the sector?	The Biotechnology Industry: South African Perspective Regulatory Environment	Key Innovation Drivers Access to Market Government Support
(4) How important do you think access to funding and financial support is in driving innovation competitiveness in the biotechnology entrepreneurship sector?	The Biotechnology Industry: South African Perspective Barriers to entry in the Biotechnology Industry	Key Innovation Drivers Funding

(5) Are there any collaborations or partnerships that play a significant role in fostering innovation competitiveness within the biotechnology entrepreneurship sector?	The Biotechnology Industry: South African Perspective Overview of the Biotechnology Landscape in South Africa Government Policies and Initiatives Promoting Innovation in the Biotechnology Sector	Key Innovation Drivers Access to Market Government Support Regulatory Factors
(6) Are there any unique challenges or opportunities specific to the South African context that influence innovation competitiveness in this sector?	The Biotechnology Industry: South African Perspective Overview of the Biotechnology Landscape in South Africa	Key Innovation Drivers Funding
(7) What market skills do you think make biotechnology innovations successful in your experience?	The Role of Market, Entrepreneurial, Technological and Market Capabilities	MET Capabilities Market Capability
(8) What entrepreneurial skills do you believe are crucial for making biotechnology innovations commercially successful?	The Role of Market, Entrepreneurial, and Technological Capabilities Entrepreneurial Capabilities	MET Capabilities Entrepreneurial Capability
(9) How do technical skills, like expertise in research and development or having the right infrastructure, help in making biotechnology	The Role of Market, Entrepreneurial, and Technological Capabilities Technological Capabilities	MET Capabilities Technological Capability
(10) Can you provide any examples of successful commercialisation of biotechnology innovations in South Africa and discuss the factors that led to their success?	The Biotechnology Industry: Global Perspective The Biotechnology Industry: South African Perspective	
(11) What factors make it easier for South African biotechnology entrepreneurs to use and apply technology-driven innovation models?	The Biotechnology Industry: South African Perspective Sources of Innovation: Technology Push and Demand-Pull	Market Supply-Demand Specific Market Trends Entrepreneurial Capability Market Capability Technological Capability
(12) What factors make it easier for South African biotechnology entrepreneurs to use and apply demand-driven innovation models?	The Biotechnology Industry: South African Perspective Sources of Innovation: Technology Push and Demand-Pull	Market Supply-Demand Specific Market Trends Entrepreneurial Capability Market Capability Technological Capability

(13) Can you identify any barriers or challenges that hinder the adoption and implementation of technology push or demand-pull innovation models in this sector?	Barriers to Entry into the Biotechnology Industry Capital Human Capital Regulatory Environment	Capital Skills Shortage
(14) Are there any specific examples or instances where the adoption of innovation models has succeeded or failed within the biotechnology	The Biotechnology Industry: South African Perspective	

Figure 4 presents the important themes from the interview transcripts that became the nodes during the data coding process using the NVivo 12 programme (Qsrinternational, 2024). During the data coding process, related information was collected under the nodes in pursuit of related patterns. In Figure 4, the sources indicate the number of research participants who talked about a specific theme and the references indicate the total number of statements in relation to a specific theme made by the various research participants.



Nodes

Name	Sources	References	Created On
Innovation Barriers	13	90	11/02/24 12:17
Skills Shortage	13	81	11/02/24 12:22
Capital	13	147	18/02/24 06:01
Key Innovation Drivers	14	462	11/02/24 12:08
Specific Market Trends	14	208	11/02/24 12:09
Regulatory Factors	14	112	11/02/24 12:10
Funding	14	179	11/02/24 12:10
Access to Market	14	109	18/02/24 05:34
Government Support	14	173	18/02/24 05:36
Market Supply-Demand	14	194	11/02/24 12:21
MET Capabilities	14	113	11/02/24 12:12
Market Capability	14	95	11/02/24 12:13
Entrepreneurial Capability	13	49	11/02/24 12:14
Technological Capability	14	68	11/02/24 12:15
Recommendations	6	24	21/02/24 04:35
Challenges	5	18	21/02/24 04:29
Opportunities	8	22	21/02/24 04:29

Figure 4: The coding framework

Source: NVivo 12 (Qsrinternational, 2024)

The important themes displayed in Figure 4 are presented and labelled in Table 4 known as the code book. Additionally, Table 4 shows how many sources and references were coded into each important theme.

Table 4: The code book showing themes

Name	Description	Sources	References
Innovation Barriers	Innovation barriers	13	90
Capital	An innovation barrier	13	147
Skills Shortage	An innovation barrier	13	81
Key Innovation Drivers	Key drivers influencing innovation competitiveness	14	462
Access to Market	A key driver influencing innovation competitiveness	14	109
Funding	A key driver influencing innovation competitiveness	14	179
Government Support	A key driver influencing innovation competitiveness	14	173
Market Supply-Demand	A key driver influencing innovation competitiveness	14	194
Regulatory Factors	A key driver influencing innovation competitiveness	14	112
Specific Market Trends	A key driver influencing innovation competitiveness	14	208
MET Capabilities	Market, entrepreneurial, and technological (MET) capabilities driving commercialisation	14	113
Entrepreneurial Capability	Entrepreneurial skills driving commercialisation	13	49

Name	Description	Sources	References
Market Capability	Market skills driving commercialisation	14	95
Technological Capability	Technological skills driving commercialisation	14	68
Recommendations	Recommendations to enhance technology drivers of innovation competitiveness in the biotechnology sector	6	24
Challenges	Challenges in the biotechnology sector in South Africa	5	18
Opportunities	Opportunities available in South Africa	8	22

Table 5 presents the research participants' opinion on the drivers influencing innovation competitiveness in biotechnology entrepreneurship. The important themes from Figure 4 are backed by quotes from the research participants and also by current literature.

Table 5: Research participants' opinion on the drivers influencing innovation competitiveness in biotechnology entrepreneurship

	Important theme	Quote	Current literature
1	Innovation Barriers	*"Socio-economic challenges." (P02)* *"So, one of the critical things that is required is ability to do market research..."* (P08)	Biotechnology research is expensive, as proper facilities and reagents are required. Attracting investors is extremely challenging due to the significant costs and risks. The risks involved with biotechnology projects are numerous, and hefty costs are often unjustified if the technology is not accepted during one of the validation stages (Zemlickiene & Turskis, 2020)
2	Capital	*"…we do find that there's resistance from Angel investors to invest..."* (P04) *"You see, they will say there's billions that have been set aside for entrepreneurs, for emerging entrepreneurs, but it's difficult to access that money."* (P05)	The start-up capital for new biotechnology enterprises could run into the millions of dollars (Uctu & Eksteen, 2022). Due to a lack of funding (including seed funding) and a dedicated body to coordinate the efforts, the industry is also perceived as underdeveloped, fragmented, and fractured.

3	Skills Shortage	*"I think it goes back to some of the skills that one needs to have."* (P01) *"You always need to learn or seek to learn.* (P14)	South Africa has exceptional scholars in terms of publications and international collaborations, but there is a need for the country to invest more in younger talent rather than just a few well-published project leaders (Uctu & Eksteen, 2022).
4	Market Supply-Demand	*"…if you are not participating in this fourth industrial revolution, not only will you be behind when it comes to the new wave of innovation..."* (P04) *"…that was purely based on what the market potential was reeling at that time…"* (P06)	The biotechnology market was expected to increase steadily at a rate of 0.8 percent from 2015 to 2020, as per figure 3 below (Patra & Muchie, 2017). Based on the above, the South African biotechnology market has been growing steadily. From 2015 to 2020, the market's overall value was expected to increase from $1.18 billion to over $1.76 billion. This indicates a positive trend and potential opportunities for entrepreneurs in the biotechnology sector.
5	Key Innovation Drivers	*"Without access to funding, the technology will never be developed."* (P02) *"…financial backup and political backup then it's easy to get right skills…"* (P05)	A biotechnology start-up requires three pillars to be successful: effective management, which includes key personnel, infrastructure, business support services; access to cutting-edge technology that results in the development of new products, which covers a solid science base and entrepreneurship culture and sufficient capital to sustain the business (Uctu & Eksteen, 2022).
6	Access to Market	*"The biggest challenge is getting access to markets..."* (P03) *"So, I think the issue of markets and access to markets influence more the entrepreneurs or industry in this country."* (P08)	Institutional, industrial, market, organisational, ownership, and governance elements are among the context-influencing factors for entrepreneurial action that have been identified (Autio et al., 2014).
7	Funding	*"Yeah, funding is very key because without it becomes difficult to have equipment to produce, equipment for research is a challenge."* (P05) *"You definitely need funding in order to get the solution out to everybody."* (P06)	High levels of research and development (R&D) funding are mostly used in the biotechnology industry. The innovation process in this sector is extremely complicated, and a variety of interactions between various types of entities play an important role in the development of biotechnology (Patra & Muchie, 2017).
8	Government Support	*"Research and development and partnering with research institutions helped us come up with our skincare range."* (P07) *"It's collaboration and partnerships between, for example, Department of Science and Innovation (DSI), the department of instruments (funding) that exists there."*	The South African National System of Innovation (NSI) functions at four levels. The government is the only actor in terms of funding, R&D performance, innovation, and evaluation (Patra & Muchie, 2017).
9	Regulatory Factors	*"I mean, if your ability to actually partner with those people, it means you have in some way either conventional or unconventional have acquired the right education."* (P11) *"The policy dictates that it must be tested by a privately owned laboratory, so as things are now..." (P13)*	The requirement for extensive safety testing, multistage clinical research, and regulatory validation places significant constraints on the development of biotechnology in the areas of human and animal health (Zemlickiene & Turskis, 2020)

10	Specific Market Trends	*"And I feel like that's the one trend that's been going."* (P04) *"I don't know if that's a driver, but people are curious and what I like about Africa, we always want to use what we have here."*	In the context of small businesses, market orientation determines the success of new products. It follows that market orientation in a biotechnology enterprise is likely to be positively correlated with product innovation (Renko, Carsrud, & Brannback, 2019).
11	Entrepreneurial Capability	*"So, we needed to do research and development to further develop the product."* (P03) *"And how easy it is to come out of research and be able to develop a product and be able to have traction in the country."* (P08)	Entrepreneurial orientation is found to have a positive influence on ground-breaking innovations in the literature. Findings imply that business owners that adopt a risk-taking and competitively proactive perspective develop novel products that are highly distinctive (Renko, Carsrud, & Brannback, 2019).
12	Market Capability	*"Understand your target market and customer needs."* (P02) *"Like for example, you have to know how to market,"* (P04)	An organisation's capacity for idea generation may be affected by elements like its entrepreneurial orientation and/or technology capabilities. Additionally, there are factors like market orientation that may have an impact on how an invention is commercialised after it has been developed (Renko, Carsrud, & Brannback, 2019).
13	Technological Capability	*"The technological capabilities..."* (P10) *"But I think if you don't have the technical skill..."* (P11)	Technology competence, which is made up of technical knowledge, trade secrets, patents, know-how developed through R&D, and other intellectual property, is what drives a company's innovation. (Renko, Carsrud, & Brannback, 2019).
14	Recommendations	The recommendations stem from the challenges and opportunities discussed in the interviews.	The requirement for extensive safety testing, multistage clinical research, and regulatory validation places significant constraints on the development of biotechnology in the areas of human and animal health (Zemlickiene & Turskis, 2020).
15	Challenges	*"It all goes back to the funding…"* (P12) *"…sometimes it's good to really understand the subject matter…"* (P08)	Funding is required to complete various stages of R&D, and the ability to accelerate development is a key aspect in defining a company's competitiveness (Khilji, Mroczkowski, & Bernstein, 2006).
16	Opportunities	*"I think there are opportunities…"* (P05) *"…you can use indigenous plants…"* (P10)	Innovation can reshape markets and create new opportunities, while being driven by a multitude of factors beyond competition alone (Pabon & Capobianco, 2023).

The subsequent segments present a discussion of the results summarised in Table 3 with respect to the research objectives.

4.3 DISCUSSION AND INTERPRETATION OF THE RESULTS

The subsequent sections present a discussion and interpretation of the results outlined in Table 3 with respect to the research objectives.

4.3.1 To explore the key drivers of innovation in the biotechnology entrepreneurship sector in South Africa

4.3.1.1 Access to market

Access to market was an important theme during the interviews with the research participants. This result is shown in Table 3. The following are quotes from the interviews supporting this finding:

"Within the space and also in my business, for instance, it would be the access to market because it's easier to produce something. But when you don't have market for it, it's pointless so retailers (private sector) are important in this regard. I think about 60% or 70% of the key players, it would be private sector which is critical for market access." (P01)

"So, it would be those stages and phases into now trying to access the market with that product. The biggest is getting access to markets, this can be attributed to lack of funding because accessing the market requires extensive marketing which means you need to pump in money to make sure that you are able to get your product out there and it doesn't just come cheap." (P03)

"Now we have the CSIR helping us to create manufacturing documents, manufacturing data pegs, standard operating procedures like compliance documents which are going to assist us with access to the mainstream retail markets and other healthcare collaborators in the space." (P06)

"Access to markets I think, based on the quality of your product will determine the ease or difficulty of your ability to penetrate the market or get access to a market. Market access becomes easier once all the regulatory requirements have been met." (P14)

Based on this result, access to market is a key driver of innovation in the biotechnology entrepreneurship sector in South Africa. However, the biotechnology industry is primarily centred in high-income countries and has been growing since the 1980s. The majority of investments in biotechnology are made by the United States and EU member states, with

developing countries accounting for less than 5% of global investments (Martin, Vicente, & Dundar, 2021).

4.3.1.2 Funding

Funding was an important theme during the interviews with the research participants. This result is shown in Table 3. The following are quotes from the interviews supporting this finding:

"With any business, I think funding is one of the important factors because it enables you to start. It gives you a kick start for whatsoever sort of direction that you're intending to take. So having to have funding, it helps in terms of improving whatsoever innovation." (P01)
"So therefore, funding is very vital. Funding is very important in this process because if you don't have that financial muscle, it will take you ages and ages to commercialise. I think there's a lot of government funding that could influence competitiveness." (P03)
"To be honest, its funding, and in South Africa… belief in the technology. I feel like the current inhibitors or factors that are either driving innovation or inhibiting innovation are one major funding because one thing we have come to realise within the biotech sector is that it is very expensive to start…" (P04)
"Yeah, for me first I can say it's funding, that's a challenge because it's difficult to get funding and funding is key for you to innovate and produce something of value that can benefit our country. So, they got a lot of support and funding…" (P05)

Based on this result, funding is a key driver of innovation in the biotechnology entrepreneurship sector in South Africa. However, early-stage funding in South Africa is often spearheaded by the government rather than by private investors. Later-stage investment is primarily provided by private equity and venture capital funds. Biotech start-ups have become more vulnerable in the past few years due to the decline in early-stage investment. The fundamental reason for this is that investors are switching to later-stage investment strategies due to a lack of private capital to invest in new and risky businesses (Uctu & Eksteen, 2022).

4.3.1.3 Government support

In addition, government support was an important theme during the interviews with the research participants. This result is shown in Table 3. The following are quotes from the interviews supporting this finding:

"I think government can play a major role. I think there's a lot of government funding that could influence competitiveness." (P03)
"The only issue is right now all we can secure as South Africans or sub-Saharan Africans is grant funds from government because we do find that there's resistance from Angel investors to invest in… technology because it's never been seen and some people still believe that there's no infrastructure for such in the country, even though there is. But also, it's being taken seriously by our funders because I feel like what you need, what government is doing is they are well intentioned, but government can only be limited..." (P04)
"You know, for example, where they encourage private public partnerships, you see then it helps the government to create conducive policies that will… enable researchers; I mean, innovators to partner and also develop their products. So funding is key in that government, I think is trying with the private sector to give some funding, but it's not enough." (P05)
"So, the partnership and collaboration institutionally, we found it has been really critical and because that's how we've been able to get support to be able to move along and we also have seen that the partnership and collaboration between companies and institutions and say private sector in this case… as an example, there is an institution called SME Fund. And then the collaboration or partnerships between R&D facilities and private companies, for example, we work with universities, we work with also government institutions." (P08)

Based on this result, government support is a key driver of innovation in the biotechnology entrepreneurship sector in South Africa. Africa continues to lag behind the rest of the globe in terms of generating new scientific knowledge (Sammut, 2021). In South Africa, the biotechnology ecosystem is made up of the government, enablers such as research institutions, incubators, business institutions, non-governmental organizations, universities, public and private funding institutions, and biotechnology firms. Funding for early-stage biotechnology entrepreneurs is significantly led by the government (Uctu & Eksteen, 2022).

4.3.1.4 Regulatory factors

Furthermore, regulatory factors were an important theme during the interviews. This result is shown in Table 3. The following are quotes from the interviews supporting this finding:

"Part of it and part of the reason why one needs to get certified. To have the SA or Global GAP certificate which says you are complying within all the agricultural acts or all the agricultural policies within the production sector." (P01)
"So, when you get the product tested, when they do the microbiological test and the nutritional test and all, that's when you start to see the importance of having those types of tests to be competitive. So, I was one of the finalists and the reason why we couldn't make it was that we didn't have clinical test done and for you to actually have clinical tests, you need to have a vast amount of funding." (P11)
"Most of the retailers, when they test my products, they realize they actually thought they're imported, only to find that no they are manufactured here in South Africa. They wanted me to do efficacy testing and then do microbiological testing. So, to protect their own reputation, they will even recommend the body where you have to take your samples or your product for testing and dermatological testing. For instance, my products are at… now, but I had to go through that testing." (P12)

Based on this result, regulatory factors are key drivers of innovation in the biotechnology entrepreneurship sector. The innovation process in this sector is extremely complicated, and a variety of interactions between various types of entities play an important role in the development of biotechnology (Patra & Muchie, 2017). For instance, there are various types of intricate connections between large corporates, emerging biotechnology companies, government research institutions, and universities. Collaboration between universities and venture capital is crucial for the effective commercialization of innovations. Apart from regulation, the innovation process in this industry is greatly influenced by laws governing intellectual property rights, patents, national health systems, and consumer demands (Patra & Muchie, 2017).

4.3.1.5 Specific market trends

And lastly, specific market trends were an important theme during the interviews with the research participants. The following specific market trends were discussed in the interviews:

- Health consciousness

- Affordability, quality, and safety

This result is shown in Table 3. The following are quotes from the interviews supporting this finding:

"But when it comes to organic or non-organic… health consciousness, in that there are people who are more concerned about what they eat…" (P01)
"There's been lesser demand of conventional farm products and people are opting for more organic products. The trend has been indigenous knowledge system (IKS) and organic products." (P11)
"And people are becoming health conscious about what they eat…" (P13)
"I feel like that's why when I say consumer confidence is… you want to look at how your product is, is your product better in terms of quality, is it better than the competitors' or the international market, is it more affordable? I feel like quality, affordability and safety of our product will drive what I believe is consumer confidence." (P04)
"Coming up with new things and all that, and you also have people coming up with new food related products, we can say that it is food technology but in fact it overlaps between food technology and biotech because when we talk about food, we need to understand what are the new trends that are there in that food…" (P10)

Based on this result, specific market trends are key drivers of innovation in the biotechnology entrepreneurship sector. An organisation's capacity for idea generation may be affected by elements like its entrepreneurial orientation and/or technology capabilities. Additionally, there are factors like market orientation that may have an impact on how an invention is commercialized after it has been developed (Renko, Carsrud, & Brannback, 2019).

4.3.2 To gain insights into the role of market, entrepreneurial and technological capabilities in driving commercialisation for biotechnology innovations as they relate to entrepreneurship in Gauteng, South Africa

4.3.2.1 Entrepreneurial capability

Entrepreneurial capability was an important theme during the interviews with the research participants. The following specific factors on entrepreneurial capability were discussed in the interviews:

- Understanding of the domain functional and business strategy
- Knowledge on funding opportunities

- Networking skills

This result is shown in Table 3. The following are quotes from the interviews supporting this finding:

"One, it would be understanding business because in most cases we sort of confuse business and corporate. If one understands business side of things or having knowledge or having to teach themselves around business. And it's also the ability to understand the market and I think it would also add up to and adapting to changes." (P01)
"An ecosystem is needed to develop such businesses, identify opportunity quickly and be agile." (P02)
"On the other side, information like about funding opportunities, for instance, about new opportunities about customer needs and that's also important like the CSIR information I received on technical manufacturing support." (P06)
"You know, because the ability to work at different levels with different people in different organisations helps to understand and helps them to understand and helps to be able to do what they have to do. So, the number one thing is the ability to engage and work with stakeholders." (P07)

According to this result, understanding of the domain functional and business strategy, knowledge on funding opportunities, and networking skills are key entrepreneurial capabilities that drive commercialisation for biotechnology innovations in South Africa.

4.3.2.2 Market capability

Market capability was an important theme during the interviews. The following specific factors on market capability were discussed in the interviews:

- Understanding of the product
- Marketing skills such as understanding of the target market, and overall market trends

This result is shown in Table 3. The following are quotes from the interviews supporting this finding:

"Market skills, I think it it's more around the understanding of what you are trying to sell to the market. I think having to understand that the product that you're trying to render out or the product that you're trying to sell to the market, if it's really necessary or it's not necessary

and the ability to adapt as well. Understanding of what you are trying to sell to the market and be able to adapt to the changing needs of the consumer." (P01)
"So, we needed to do research and development to further develop the product. The market didn't know what it needed until they were out there in the market." (P03)
"And your target market, it will depend on who are those people are they educated or not educated and all that. So, you must adapt to your target market. And if that partnership was not there, I don't know where we were going to go because now, we got the skill from the institution which developed our company." (P05)
"So one of the critical things that is required is ability to do market research, you know to really understand and the pain point and the market that you are getting into and what the customers will be willing to part with in the main in South Africa for a solution that you are bringing…" (P08)

The above result show that understanding of the product and having marketing skills such as understanding of the target market, and overall market trends are key marketing capabilities that drive commercialisation for biotechnology innovations.

4.3.2.3 Technological capability

In addition, technological capability was an important theme during the interviews. The following specific factors on technological capability were discussed in the interviews:

- Research and development
- Innovative solutions

This result is shown in Table 3. The following are quotes from the interviews supporting this finding:

"Solutions for agriculture affects trends in terms of innovation and then now we see a lot of us are coming through in terms of innovators and researchers looking for environmental type of solutions. And how easy it is to come out of research and be able to develop a product and be able to have traction in the country." (P08)
"You cannot commercialise a product that is not a really well researched and developed. But because we were able to think and then look at the future, we have to think about the technological capabilities, which is research and development." (P10)
"So, it's crucial to have a strong research and development team around you to help and then do the research on that thing that you want to do. I recommend that entrepreneurs should

have their own plant where they can be in full control, because when you outsource, you don't see what is really happening there." (P12)

This result shows that research and development, and innovative solutions are key technological capabilities that drive commercialisation for biotechnology innovations in Gauteng.

4.3.3 To examine the enablers and constraints with respect to technology drivers of innovation in biotechnology entrepreneurship and their impact on technology push and demand-pull models.

This section presents the challenges and opportunities that enable and constrain innovation competitiveness in the biotechnology sector and how these impact technology push and demand-pull innovation models.

4.3.3.1 Challenges in the biotechnology sector in South Africa

The research participants discussed the following challenges in the biotechnology sector in South Africa during the interviews:

- Access to funding
- Skills shortage
- Difficulty of entrepreneurs from certain racial groups in penetrating the biotechnology sector
- Low uptake of novel technologies introduced in South Africa
- Unrealistic and stringent regulatory standards
- Lack of infrastructure
- Social challenges such as lack of interest in entrepreneurship
- Access to markets
- Inconsistency in electricity supply

This result is shown in Table 3. The following are quotes from the interviews supporting this finding:

"It all goes back to the funding; without it you can't do anything. You are limited. Even now I'm stretched with other things that I want to do because of funding." (P12)

"...sometimes it's good to really understand the subject matter quite deeply for a while to be able to navigate the innovation system. But what I've seen more also is not only biotech and the technical skill, but also the team has skills called problem solving." (P08)

"We have a very difficult background in South Africa of being restricted as a population in the black population." (P13)

"We do come up with novel technologies, but the uptake is not there." (P13)

"I think legislation. Once again, probably with both models. Regulatory red tape, that's probably a big one. Access to funding, going back to that funding for R&D purposes, that's also a big one. And then obviously commercialisation." (P14)

"Yes, I think infrastructure is the main one. For instance, institutions like the CSIR, they have everything that I need to produce. What the industry needs, but it's quite expensive then to have access to that infrastructure." (P09)

"I would say it's the mindset of South Africans towards entrepreneurship. Support system as well, the mentoring, for instance, I've been fortunate because I've been mentored from then till now and this has been instrumental in the growth of the business. The rest I would say is just set up beliefs in South Africa because entrepreneurship is a difficult thing." (P06)

"The biggest is getting access to markets, this can be attributed to lack of funding because accessing the market requires extensive marketing which means you need to pump in money to make sure that you are able to get your product out there and it doesn't just come cheap." (P03)

"I think this goes across the board because like energy security affects all entrepreneurs." (P02)

Based on the results of this study, challenges in the biotechnology sector in South Africa include the following: accessing funding, skills shortage, difficulty of entrepreneurs from certain racial groups in penetrating the biotechnology sector, low uptake of novel technologies introduced in South Africa, unrealistic regulatory standards, lack of infrastructure, social challenges such as lack of interest in entrepreneurship, accessing markets, and lack of constant electricity. These challenges hinder the development and advancement of biotechnology innovations and highlight the difficulties faced by entrepreneurs in pushing their technologies forward due to systemic issues. According to Uctu and Eksteen (2022) biotechnology start-ups are of the view that there is currently no actual ecosystem that supports the biotechnology industry in South Africa, which is not conducive to innovation because innovation is not merely a product, but an environment.

4.3.3.2 Opportunities available in the biotechnology sector in South Africa

The research participants discussed the following opportunities available in the biotechnology sector in South Africa during the interviews:

- Growing market
- Resource endowment
- Potential government support

This result is shown in Table 3. The following are quotes from the interviews supporting this finding:

"And then the other thing in terms of opportunities, I think the market is there for me." (P05)
"But when it comes to opportunities, we all know that the products we are selling were actually used by our indigenous people back then. So, the opportunity is that you can use indigenous plants to establish a sustainable business." (P10)
"Yes, academia and government. I think those are the two most important ones. So, government from a regulatory aspect... Lending credence when engaging with the regulator and in this instant SAHPRA, 100% shareholder which is the Department of Health. As well as allowing for access to markets." (P14)

Based on the results of this study, opportunities available in the biotechnology sector in South Africa include a growing market, resource endowment, and government support and these serve as enablers within the demand-pull model. These factors create a conducive environment for innovation by stimulating the demand for biotechnology innovations. Biotechnology is one of the world's fastest-growing industries (Howard et al., 2021). The government should eliminate corruption, remove ties with old unsustainable networks, and transform the biotechnology landscape to be less politicised (Uctu & Eksteen, 2022).

4.3.3.3 Recommendations

Based on the challenges and opportunities in the biotechnology sector in South Africa, the following are recommendations to enhance technology drivers of innovation competitiveness in biotechnology entrepreneurship in Gauteng, South Africa:

- The government should collaborate with other stakeholders, i.e. private sector to increase access to funding for entrepreneurs in the biotechnology sector in South Africa.

- The government through business incubation programmes should facilitate networking opportunities and mentorship programs that connect aspiring biotechnology entrepreneurs with experienced professionals in the field. Mentorship can provide valuable guidance, support, and knowledge transfer to help address skills gaps.
- Through the enforcement of existing legislation, the government should ensure that previously disadvantaged groups have access to funding into sectors such as the biotechnology sector in South Africa.
- Continually encourage 'Buy SA' to promote novel technologies introduced in South Africa.
- Continually review the current regulatory standards to promote innovation in the biotechnology sector in South Africa.
- Continuous investment in modern sustainable infrastructure in the country.
- Continually promote the benefits and importance of entrepreneurship to citizens, and to the entire economy, particularly in science and technology related fields.
- Continually create partnerships and trade relations that will facilitate new market access for biotechnology entrepreneurs in South Africa.
- The government should deal with the country's power shortage to guarantee energy security.

4.4 CONCLUSION

Chapter 4 has presented, interpreted, and discussed the results of this study. Based on the results of the study, access to market is a key driver of innovation in the biotechnology entrepreneurship sector in South Africa. In addition, understanding of the domain functional and business strategy, knowledge on funding opportunities, and networking skills are key entrepreneurial capabilities that drive commercialisation for biotechnology innovations in South Africa. Additionally, understanding of the product, and having marketing skills such as understanding of the target market, and overall market trends are key marketing capabilities that drive commercialisation for biotechnology innovations in South Africa. Furthermore, research and development, and innovative solutions are key technological capabilities that drive commercialisation for biotechnology innovations in South Africa. In addition, the study examined the key enablers and constraints in the sector and their impact on technology push and demand-pull innovation models. Chapter 5 presents the conclusions and recommendations of the study.

CHAPTER 5: CONCLUSION & RECOMMENDATIONS

5.1 INTRODUCTION

This research, as discussed in Chapter 1, to investigate the drivers influencing innovation competitiveness in biotechnology entrepreneurship and evaluate the relevance and effectiveness of technology push and demand-pull innovation of biotechnology entrepreneurship in Gauteng, South Africa.

The study was able to establish the following in line with the research questions, as outline in chapter 1:

i. **What key drivers influence innovation competitiveness within the biotechnology entrepreneurship sector in South Africa?**

The study identified several key drivers influencing innovation competitiveness within the biotechnology entrepreneurship sector in South Africa:

Access to Market: The research revealed that access to market is a crucial driver of innovation in the biotechnology entrepreneurship sector. Quotes from participants emphasized the significance of market access, particularly through collaborations with private sector entities.

Funding: Funding emerged as another essential driver, with participants emphasizing its importance for starting, improving, and accelerating innovations. The study noted that government funding plays a significant role in the early stages of biotech startups in South Africa.

Government Support: The study highlighted the role of government support as a key driver. Participants pointed out that government funding, particularly through grant funds, is essential for innovation in the biotechnology sector. Public-private partnerships were also emphasized.

Regulatory Factors: Regulatory factors, including compliance with agricultural acts and quality certifications, were identified as drivers. The study found that adhering to regulatory standards is crucial for market competitiveness.

Specific Market Trends: Market trends, such as health consciousness, affordability, quality, and safety, were recognized as drivers of innovation. Participants discussed how adapting to these trends is essential for staying competitive in the biotechnology entrepreneurship sector.

ii. **What market, entrepreneurial, and technological capabilities drive the commercialization of biotechnology innovations in the context of entrepreneurship in Gauteng, South Africa?**

The study delved into market, entrepreneurial, and technological capabilities that drive the commercialization of biotechnology innovations in Gauteng, South Africa:

Entrepreneurial Capability: The research highlighted the importance of entrepreneurial capabilities such as understanding business, knowledge of funding opportunities, and networking skills. These capabilities contribute to navigating the innovation system and adapting to changes.

Market Capability: Understanding the product and possessing marketing skills, including knowledge of the target market and overall market trends, were identified as key market capabilities driving commercialization.

Technological Capability: Research and development and innovative solutions were recognized as crucial technological capabilities driving the commercialization of biotechnology innovations.

iii. **What are the key enablers and constraints related to technology drivers in biotechnology entrepreneurship, and how do they impact the technology push and demand-pull models of innovation?**

The study identified key enablers and constraints related to technology drivers in biotechnology entrepreneurship:

Enablers:

Growing Market: The growing market in South Africa was recognized as an opportunity, serving as an enabler for innovation in the biotechnology sector.

Resource Endowment: The availability of resources, particularly indigenous plants, was highlighted as an opportunity for establishing sustainable businesses in biotechnology.

Constraints:

Access to Funding: Limited access to funding was identified as a significant constraint affecting the biotechnology sector, potentially hindering innovation and growth.

Skills Shortage: A shortage of skills, particularly in certain racial groups, was recognized as a challenge in the biotechnology sector.

Regulatory Standards: Unrealistic and stringent regulatory standards were identified as constraints impacting innovation competitiveness.

Additionally, in terms of the impact on the technology push model, challenges such as access to funding, skills shortage, unrealistic regulatory standards, lack of infrastructure, and inconsistent electricity supply act as constraints within the technology push model. These challenges hinder the development and advancement of biotechnology innovations. These challenges highlight the difficulties faced by entrepreneurs in pushing their technologies forward due to systemic issues. In relation to the demand-pull model, opportunities such as a growing market, resource endowment, and potential government support serve as enablers within the demand-pull model. These factors create a conducive environment for innovation by stimulating the demand for biotechnology innovations.

The preceding sections of this chapter demonstrate that all the research aims and objectives that were outlined at the beginning of this study have been addressed, and therefore, the research objectives of this study have been satisfied.

5.2 RECOMMENDATIONS

Based on the results of this study, the following are recommendations are proposed for government, academia and entrepreneurs.

Access to Funding:

The government holds a pivotal role in fostering collaboration between public and private sectors to bolster financial support for biotechnology entrepreneurs in South Africa. By actively seeking partnerships with private investors, venture capitalists, and corporate entities, the government can significantly amplify funding opportunities for startups operating in the biotechnology sector. These collaborations not only expand the pool of available resources but also leverage the expertise and networks of private sector stakeholders to nurture innovation and entrepreneurship, as government funding is limited.

Inclusivity:

Rigorous enforcement of existing legislation is essential to ensure equitable access to funding and resources in the biotechnology sector, particularly for historically disadvantaged groups. The government needs to uphold laws that promote diversity and inclusivity, as a way to demonstrate its commitment to levelling the playing field and fostering a supportive environment for aspiring entrepreneurs from all backgrounds.

Regulatory Standards:

Regular reviews of regulatory standards are imperative to facilitate innovation and progress in the biotechnology sector. A dynamic regulatory framework that accommodates advancements in technology not only encourages entrepreneurship but also ensures that emerging biotechnology innovations can navigate regulatory processes efficiently. Regulatory authorities such as SAHPRAH, which are key to the biotechnology sector should embrace flexibility and responsiveness in some of the regulatory standards, this was entrepreneurs will be encouraged to push novel and groundbreaking technology solutions with confidence.

Sustainable Infrastructure:

A sustained effort to invest in modern and sustainable infrastructure is crucial to support the growth and competitiveness of the biotechnology sector. By prioritizing infrastructure development across the country, the government creates an enabling environment for biotech startups to thrive. From research facilities to manufacturing hubs, robust infrastructure enhances the sector's capacity for innovation, collaboration, and global engagement.

Promotion of Entrepreneurship:

Consistent promotion of the benefits and importance of entrepreneurship, especially in science and technology-related fields, is essential to inspire and empower the next generation of innovators. Academia and government through its business development and technology incubation programmes can raise awareness among citizens about the transformative potential of entrepreneurship to instil an entrepreneurial mindset and cultivate a culture of innovation. This could be done through educational campaigns, outreach programs, and strategic partnerships.

Facilitation of Market Access:

Active efforts to forge partnerships and trade relations play a pivotal role in expanding market access for biotechnology entrepreneurs in South Africa. The government can facilitate strategic alliances with foreign markets and create market opportunities for local startups. Moreover, the government could serve as the initial off-take market for biotechnology innovations needed within the public sector.

5.3 SUGGESTION FOR FURTHER STUDIES

This research report focused on a qualitative study on technology drivers of innovation competitiveness in biotechnology entrepreneurship. Future studies could be expanded to include comparative studies with other developing countries that have thriving biotechnology sectors, these could offer valuable insights for South Africa. Other studies could include case studies of successful biotechnology companies in Gauteng to offer practical guidance and lessons for individuals aspiring to become entrepreneurs.

5.4 CONCLUSION

In summary, the findings underscored the nuanced interplay between various factors shaping innovation competitiveness and commercialization in biotechnology entrepreneurship. This study provides valuable insights for policymakers, industry stakeholders, and entrepreneurs seeking to foster a conducive environment for biotechnology innovation and entrepreneurship in South Africa. Overall, the findings contribute to a deeper understanding of the dynamics driving innovation in the biotechnology sector and offer actionable recommendations to enhance its competitiveness and sustainability in the country.

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APPENDIX A: Research Instrument

Question 1: Background Questions
1.1 What is your educational background?
1.2 Please share your experience and role in the biotechnology entrepreneurship field and the industry in which you operate.
1.3 How well do you know the biotechnology entrepreneurship sector's innovation landscape and its level of competitiveness?
Question 2: Key Drivers Influencing Innovation Competitiveness
2.1 In your opinion, what are the main factors or drivers that influence innovation competitiveness within the biotechnology entrepreneurship sector?
2.2 Can you identify any specific market trends or demands that drive innovation competitiveness in this sector?
2.3 Are there any regulatory or policy factors that have an impact on the innovation competitiveness in the sector?
2.4 How important do you think access to funding and financial support is in driving innovation competitiveness in the biotechnology entrepreneurship sector?
2.5 Are there any collaborations or partnerships that play a significant role in fostering innovation competitiveness within the biotechnology entrepreneurship sector?
2.6 Are there any unique challenges or opportunities specific to the South African context that influence innovation competitiveness in this sector?
Question 3: Market, Entrepreneurial, and Technological Capabilities Driving Commercialization
3.1 What market skills do you think make biotechnology innovations successful in your experience?
3.2 What entrepreneurial skills do you believe are crucial for making biotechnology innovations commercially successful?
3.3 How do technical skills, like expertise in research and development or having the right infrastructure, help in making biotechnology innovations successful commercially?
3.4 Can you provide any examples of successful commercialization of biotechnology innovations in

South Africa and discuss the factors that led to their success?

Question 4: Factors Facilitating or Hindering Innovation Models in Biotechnology Entrepreneurship

4.1 What factors make it easier for South African biotechnology entrepreneurs to use and apply technology-driven innovation models?

4.2 What factors make it easier for South African biotechnology entrepreneurs to use and apply demand-driven innovation models?

4.3 Can you identify any barriers or challenges that hinder the adoption and implementation of technology push or demand-pull innovation models in this sector?

4.4 Are there any specific examples or instances where the adoption of innovation models has succeeded or failed within the biotechnology entrepreneurship sector in South Africa?

Conclusion

Is there any additional information or perspectives you would like to share regarding the key drivers influencing innovation competitiveness in the biotechnology entrepreneurship sector in South Africa?

APPENDIX B: Consent Form

Title: Technology drivers of innovation competitiveness in biotechnology entrepreneurship in Gauteng, South Africa

I, …….., agree to participate in this research project. The research has been explained to me and I understand what my participation will involve. I agree to the following:

(Please circle the relevant options below).

I agree that my participation will remain anonymous	YES	NO
I agree that the researcher may use anonymous quotes in his / her research report	YES	NO
I agree that the interview may be audio recorded	YES	NO
I agree that the information I provide may be used in an anonymized format after this project has ended, for academic purposes by other researchers, subject to their own ethics clearance being obtained.	YES	NO

…… (signature)
…… (name of participant)
…… (date)

…… (signature)
…… (name of person seeking consent)
…… (date)

APPENDIX C: Participant Information Sheet

Good day,

My name is Sibahle Tile and I am a Masters student in Business Administration at the University of the Witwatersrand, Johannesburg. As part of my studies, I have to undertake a research project, and the title of my research is Technology drivers of innovation competitiveness in biotechnology entrepreneurship in Gauteng, South Africa under the supervision of Dr. Ademola Ayodele. The aim of this research project is to investigate the drivers influencing innovation competitiveness in biotechnology entrepreneurship and evaluate the relevance and effectiveness of technology push and demand-pull innovation of biotechnology entrepreneurship in Gauteng, South Africa.

As part of this project, I would like to invite you to take part in an interview. This activity will involve semi-structured open-ended questions and will take around 60 minutes. With your permission, I would also like to audio record the interview using a digital device. This recording will be stored in a portable USB and only the researcher will have access to this recording. It will be deleted after one year.

There will be no personal costs to you if you participate in this project. You will not receive any direct benefits from participation but there are no disadvantages or penalties if you do not choose to participate or if you withdraw from the study. You may withdraw at any time or not answer any question if you do not want to. The interview will be completely confidential and anonymous as I will not be asking for your name or any identifying information, and the information you give to me will be held securely and not disclosed to anyone else. I will be using a pseudonym (false name) to represent your participation in my final research report. If you experience any distress or discomfort at any point in this process, we will stop the interview or resume another time.

If you have any questions during or afterwards about this research, feel free to contact me on the details listed below. This study will be written up as a research report which will be available online through the university library website. If you wish to receive a summary of this report, I will be happy to send it to you (optional). With your permission the data collected from this research project may be used by other researchers in an anonymized format. If you have any concerns or complaints regarding the ethical procedures of this study, you are welcome to contact the University Human Research Ethics Committee (Non-Medical), telephone +27(0) 11 717 1408, email hrecnon-medical@wits.ac.za

Yours sincerely,
Sibahle

Researcher:
Sibahle Tile, 769062@students.wits.ac.za

Supervisor:
Dr. Ademola Ayodele, ademola.ayodele@wits.ac.za

APPENDIX D: Ethics Approval

Graduate School of Business Administration
University of the Witwatersrand, Johannesburg

Wits Business School

Wits Business School Ethics Committee
Constituted under the University Human Research Ethics Committee (Non-Medical)

Ethics Clearance Certificate

Ethics protocol number: WBS/BA769062/281
This certificate is only valid with a legitimate ethics protocol number and signed by the Researcher (below)

Project title	Technology drivers of innovation competitiveness in biotechnology entrepreneurship in Gauteng, South Africa
Investigator / Researcher	Ms Sibahle Tile
Nature of Project	MBA (Research Article)
Decision of the Committee	Approved, provided stakeholders and participants are guaranteed confidentialty.
Issue Date of Certificate	2024/02/05
Expiry date	Date of submission of the project / research report
Chairperson	Dr Pius Oba ☎ +27 11 717 3976 +27 82 733 6587 pius.oba@wits.ac.za

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Declaration by Researcher

One copy must be signed by the Researcher and returned to the Chairperson of the Wits Business School Ethics Committee.

I fully understand the conditions under which I am authorized to carry out the abovementioned research and I guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I undertake to resubmit the protocol to the Committee.

Signature

05-02-2024
Date:

APPENDIX E: Organization Request for Approval

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

University of the Witwatersrand
Wits Business School
Faculty of Commerce, Law and Management
+27 (0) 11 717 1087

Mr. Thibi Matshele
Acting Chief Executive Officer
The Innovation Hub
1 Mark Shuttleworth St.
Lynnwood
Pretoria
0087

15 August 2023

Dear Mr. Matshele,

Re: Permission to conduct research at The Innovation Hub, BioPark@Gauteng Business Incubator.

I am studying for a Master of Business Administration (MBA) in the Faculty of Commerce, Law and Management at the University of the Witwatersrand. I am seeking permission to do research at The Innovation Hub, specifically the BioPark@Gauteng Business Incubator.

I am conducting research on **Innovation as a driver of competitiveness in biotechnology start-ups in Gauteng**. The research aims to investigate the drivers influencing innovation competitiveness in biotechnology start-ups and evaluate the effectiveness of technology push and demand pull innovation of biotechnology start-ups in Gauteng.

Overall, the study seeks to uncover the driving force behind innovation in biotechnology start-ups in Gauteng and assess the significance of technology push and demand pull approaches. The findings will shed light on the intricacies of biotechnology innovation models and their impact on commercialisation, promote informed decision-making, pave the way for future research and interventions and enable focused implementation of strategies for the BioPark@Gauteng Incubator, aimed at fostering innovation and entrepreneurial growth in this critical sector.

I would like to request permission to get access to the list of biotechnology entrepreneurs incubated at BioPark@Gauteng.

Participants will be asked to give their written or verbal consent before the research begins. Their responses will be treated confidentially, and identities (their names and the name of their companies) will be anonymous unless otherwise expressly indicated. Individual privacy will be maintained in all published and written data resulting from the study.

The results will be communicated in the dissertation and will be shared in due course.

The research participants will not be advantaged or disadvantaged in any way. They will be reassured that they can withdraw their permission at any time during this project without any penalty. There are no foreseeable risks in participating in this study.

I therefore kindly request permission in writing to conduct my research at The Innovation Hub. The permission letter should be on your organization's letterhead, signed and dated, and specifically referring to myself by name and the title of my study (*Innovation as a driver of competitiveness in biotechnology start-ups in Gauteng*).

Please let me know if you require any further information. I look forward to your response as soon as is convenient.

Yours Sincerely,

Sibahle Tile

Researcher:
Sibahle Tile
769062@students.wits.ac.za

Supervisor:
Dr. Asabea Ahwireng-Obeng
asabea.ahwireng-obeng@wits.ac.za

APPENDIX F: Organization Approval

THE INNOVATION HUB
Innovation Catalyst for Gauteng City Region
A subsidiary of the Gauteng Growth and Development Agency

Ms. Sibahle Tile
University of the Witwatersrand
Wits Business School
Faculty of Commerce, Law and Management

Dear Ms. Tile

Re: Permission to conduct research at The Innovation Hub, BioPark@Gauteng Business Incubator.

Reference is made to your letter of 15th August 2023 on the above subject.

In my capacity as Acting CEO of The Innovation Hub, I grant permission to Sibahle Tile to conduct research/ access to the list of biotechnology entrepreneurs incubated at BioPark@Gauteng.

The following information is agreed upon by the researcher and the organization:

Permission is hereby granted to Ms. Tile to conduct research on **Innovation as a driver of competitiveness in biotechnology start-ups in Gauteng**. The research aims to investigate the drivers influencing innovation competitiveness in biotechnology start-ups and evaluate the effectiveness of technology push and demand-pull innovation of biotechnology start-ups in Gauteng.

Overall, the study seeks to uncover the driving force behind innovation in biotechnology start-ups in Gauteng and assess the significance of technology push and demand-pull approaches. The findings will shed light on the intricacies of biotechnology innovation models and their impact on commercialisation, promote informed decision-making, pave the way for future research and interventions and enable focused implementation of strategies for the BioPark@Gauteng Incubator, aimed at fostering innovation and entrepreneurial growth in this critical sector.

Participants will be asked to give their written or verbal consent before the research begins. Their responses will be treated confidentially, and identities (their names and the name of their companies) will be anonymous unless otherwise expressly indicated. Individual privacy will be maintained in all published and written data resulting from the study.

The results will be communicated in the dissertation and will be shared in due course.

The research participants will not be advantaged or disadvantaged in any way. They will be reassured that they can withdraw their permission at any time during this project without any penalty. There are no foreseeable risks in participating in this study.

We are looking forward to seeing the results of the study.

Yours Faithfully,

Mr. Mothibedi Matshele
Acting Chief Executive Officer (TIHMC)
Date