ABSORPTIVE CAPACITY AND GROWTH NEXUS IN THE SOUTH AFRICAN PHARMACEUTICAL SECTOR: AN INTRA-INDUSTRY TRADE PERSPECTIVE

By

NWABISA MALIMBA

[21M7218]

A thesis submitted in fulfillment of the requirements of the degree of

DOCTOR OF PHILOSOPHY

In the

FACULTY OF COMMERCE

DEPARTMENT OF ECONOMICS AND ECONOMIC HISTORY

RHODES UNIVERSITY

MAKHANDA

Supervisor: Prof. T.E. Mutambara

Co-supervisor: Prof J. Marire

April 2025

DECLARATION

I, NWABISA MALIMBA [21M7218], hereby declare that this thesis titled '*Absorptive Capacity and Growth nexus in the South African Pharmaceutical Sector: An Intra-Industry Trade Perspective,'* forms the basis of my Degree of Doctor of Philosophy, is a product of my own conceptualization and execution, with the exception for quotations and citations that have been appropriately acknowledged. Furthermore, I confirm that this work has not been submitted to another university or any other qualification.

NWABISA MALIMBA

DATE: April 2025

ACKNOWLEDGEMENT

This journey had many life-changing challenges, but it has also been enriched with wonderful experiences and cherished memories. I am grateful to the Lord Almighty for His faithfulness in giving me the strength to persevere through it all. The scripture that carried me through is in Philippians 4:13: "*I can do all things through Christ who strengthens me*."

I sincerely thank my supervisors, Prof T.E. Mutambara and Prof. J. Marire, for invaluable guidance and persistent enthusiasm even under frustrating circumstances. Your patience and positivity propelled me ahead.

I want to express my heartfelt gratitude to my family, Omelele, Enzokuhle, and Oyisa, for their patience and understanding throughout this demanding journey. Your presence in my life gave me direction and focus, which contributed to ensuring the completion of the project. Thank you so much, I love you to the moon and back! May the Lord bless you abundantly.

My siblings, friends, and parents believed in me from the beginning and gave me massive support and love during this demanding experience. Thank you for never leaving my side and for your prayers. Having you in my life gives me the emotional stability essential for executing a task of this magnitude.

My colleagues at Rhodes University have been amazing! Thank you for the coffee breaks and conversations that greatly contributed to the execution and success of this thesis. Your support has been remarkable. Working with you is an absolute pleasure.

DEDICATION

This thesis is dedicated to my family, friends, and colleagues, who have been my greatest source of support and inspiration.

ABSTRACT

South Africa is the largest pharmaceutical producer in Africa, with a market exceeding $3.9 billion and around 128 companies, including Aspen Pharmacare and Adcock Ingram. However, the industry heavily relies on imports for Active Pharmaceutical Ingredients (APIs) and some finished products, exposing it to external shocks, higher prices, and counterfeit products, leading to reduced domestic manufacturing. In recent decades, the sector has engaged in intra-industry trade (IIT), which is believed to spur innovation and facilitate the adoption of advanced technologies. IIT also increases the capacity to absorb external knowledge, stimulates growth by integrating more sophisticated production techniques, and expands market reach. The study assessed the relationship between absorptive capacity and growth through IIT covering 2002-2021. This was achieved by addressing five goals of the research, which are (i) measuring IIT and identifying its key driving factor, (ii) determining the comparative advantage within the South African pharmaceutical sector and pharmaceutical trade complementarity with other African countries, (iii) identifying determinants of absorptive capacity, (iv) establishing the relationship between IIT and absorptive capacity, (v) and examining the effect of IIT and absorptive capacity on the growth of the South African pharmaceutical industry.

To address the first objective, the study utilized the Marginal Intra-Industry Trade (MIIT) index and Unmatched Changes in Trade (UMCIT) to assess how new imports are matched by exports. The findings revealed a low proportion of new matching trade, indicating that trade is mostly inter-industry with limited specialisation. Subsequently, the study identified productivity as a key driver of exports needed to improve IIT in the South African pharmaceutical sector. Using the Malmquist Total Factor Productivity (MTFP) index, the study found that productivity is mainly driven by technical changes. Periods of high Total Factor Productivity correlated with significant intra-industry trade and specialisation in the sector.

The second objective was addressed by employing the Normalized Revealed Comparative Advantage Index, comparing South Africa to 17 countries, made up of six African, three emerging, and eight developed countries. The results indicated that South Africa has no comparative advantage in producing pharmaceutical products, with a comparative disadvantage in producing products under the category HS3004. However, there is potential to specialise in producing products in categories HS3005 and HS3001. Egypt, Tunisia, Morocco, and Nigeria are the only African countries that showed some comparative advantage in producing

pharmaceuticals. The study subsequently measured pharmaceutical trade complementarity between South Africa and selected African and emerging countries. The results revealed a strong alignment in trade, providing insights for promoting intra-African trade in pharmaceuticals under the AfCFTA agenda.

To address the third to the fifth objectives, the study used the Partial Least Squares-Structural Equation Model (PLS-SEM) to examine the determinants of absorptive capacity, its relationship to intra-industry trade, and how this relationship affects growth in South Africa's pharmaceutical sector. The findings revealed that Trade Barriers, Research and Development share (R&D), Institutional Quality, Foreign Direct Investment, and the Number of Patent applications are key determinants of absorptive capacity in the pharmaceutical sector. Additionally, the results showed that absorptive capacity mediates the relationship between intra-industry trade and growth. Furthermore, low intra-industry trade negatively affects industry growth.

The findings of this study are relevant for achieving the shared objective of the PMPA and the African Continental Free Trade Area (AfCFTA) of improving access to medicines and healthcare products across the African continent, which provides an opportunity for South Africa to establish and uphold a connection between trade and health within the continent. The study recommends strategically aligning international technology with local innovation and emphasizes the need for strong government support in R&D investment and infrastructure. South Africa requires a sustainable innovation system to ensure consistent technological improvements to enhance intra-industry trade, rather than relying on crises like HIV/AIDS and COVID-19 for technological advancements.

JEL codes: F11, F14; L23, B17, C02, M20

Keywords: Absorptive Capacity, Intra-Industry Trade, Growth, Comparative advantage, Pharmaceutical sector, South Africa, Normalized Revealed Comparative Advantage, Structural Equation Model.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

AfCFTA	African Continental Free Trade Agreement
API	Active Pharmaceutical Ingredients
AVE	Average Variance Extracted
ART	Antiretroviral Therapy
BRCA	Balassa's Revealed Comparative Advantage
CAVA	Comparative Advantage in Value-Added
COHRED	Council on Health Research for Development
CFA	Confamatory Factor Analysis
CR	Composite Reliability
DEA	The Data Envelopment Analysis
DOH	Department of Health
DTI	Department Trade and Industry
EHRs	Electronic Health Records
EU	European Union
FDA	Food and Drug Administration
FDI	Foreign Direct Investment
GLI	Grubel-Lloyd Index
GNI	Gross National Income
HDI	Human Development Index
HFMA	Health Financial Management Association
HSF	Helen Suzman Foundation
IIT	Intra-Industry Trade
MCC	Medicines Control Council
MIIT	Marginal Intra-Industry Trade
MTFP	This study used the Malmquist Total Factor Productivity
MNCs	Multinational Corporations
NEPAD	New Partnership for Africa's Development
NRCA	Normalized Revealed Comparative Advantage
PACAP	Potential Absorptive Capacity

PCT	Product Cycle Theory
PLS-SEM	Partial Least Squares
PMPA	Pharmaceutical Master Plan for Africa
PMA	Pharmaceutical Manufacturers' Association
RBA	Risk-Based Assessment
RACAP	Realised Absorptive Capacity
RCA	Revealed Comparative Advantage
R&D	Research & Development
SABS	South African Bureau of Standards
SADC	Southern African Development Community
SAMMDRA	South African Medicines and Medical Devices Regulatory Authority
SAHPRA	South African Health Products Regulatory Authority
SANAS	South African National Accreditation System
SARB	South African Reserve Bank
SEM	Structural Equation Model
TCI	Trade Complementarity Index
TNCs	Transnational Corporations
TRB	Trade Barriers
TRIPS	Trade-Related Aspects of Intellectual Property Rights
UNMCIT	Unmatched Changes in Trade
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
WDI	World Development Indicators
WHO	World Health Organisation
WTO	World Trade Organisation
4IR	Fourth Industrial Revolution

CHAPTER 1
General Overview of the Research

1.1 Introduction

The South African pharmaceutical sector has evolved over the past two decades due to changes in local and global dynamics. Central to these dynamics is the role played by intra-industry trade (IIT), which is the simultaneous exchange of products within the industry. IIT exposes firms to diverse knowledge sources and international best practices. This exposure enhances the firms' capacity to absorb new knowledge, be innovative, integrate advanced technologies, and facilitate industrial upgrading and expansion (Gupta *et al.*, 2022). Even regions with low industrialization and income can still achieve significant industrial and economic growth if they strategically enhance their absorptive capacities by improving their ability to internalize external R&D and innovation (Ferreira Moutinho, 2016).

Similarly, the positive impact of international trade on economic growth has been scrutinized in economic literature over the past decades. Scholars such as Purnama and Yao (2019), Gokmenoglu *et al*. (2015), Kónya (2006), and Balassa (1978) have indicated a positive relationship between outward-oriented trade policy, national output, and economic growth. The theoretical work contributed by classical and neoclassical economists, David Ricardo (1821), Eli Heckscher (1919), and Bertil Ohlin (1933) provided the basis for the understanding of this relationship.

Ricardo (1821) introduced the theory of comparative advantage, arguing that trade can be mutually beneficial as long as the country specialises in producing and exporting goods for which it has the lowest opportunity cost[1]. The theory of comparative advantage, which assumes labour as the only input in production, fundamentally emphasizes labour productivity as the basis for trade between countries. Ricardo (1921) further argues that even if one country is less productive in all goods, it can still benefit from trade if it specializes in goods with a relative productivity advantage (Ruffin, 2002). While the theory provides a strong foundation for why trade can be mutually beneficial, its narrow assumption limits its applicability in modern economies where production functions are multi-dimensional and influenced by more than just labour inputs (Costinot & Donaldson, 2012).

[1] Opportunity cost is the cost of foregone alternatives to produce one more unit of a particular good.

To overcome the limitation of the comparative advantage, the Heckscher-Ohlin model, introduced by Heckscher (1919) and further developed by Ohlin (1933), focused on the differences in factor endowments between countries as the basis for trade. The model proposes that countries export goods that use their abundant factors and import goods that use their scarce factors. Unlike Ricardo (1921), the Heckscher-Ohlin model predicts that trade patterns are based on resource availability, with factor endowments as a key to understanding trade patterns. The traditional trade theories form a foundational framework for the analysis of international trade, each adding layers of complexity and practicality to the understanding of why and how countries engage in trade.

After the Heckscher–Ohlin model, various contemporary trade models have emerged. One of these models is the Imitation Lag Hypothesis, introduced by Posner (1961), which focuses on the product rather than the production inputs. The Imitation Lag theory extends Heckscher-Ohlin's analysis by recognizing that trading countries have different technologies. Posner(1961) further posits that the inventing country temporarily enjoys advantages when introducing a new product, while firms in the importing country still learn to imitate the new product. The Imitation Lag theory assumes that trading countries share similar tastes and preferences and incorporates time and demand adjustments. There are two major dimensions considered in this theory. The time dimension (the imitation lag) refers to the time required for the importing country to replicate the production model that the exporting country's firms introduced. The demand dimension (demand lag) refers to the time needed for consumers in the importing country to embrace and use the new product as a close substitute for the products they currently consume (Posner,1961).

The time dimension is critical in understanding technology transfer and the catch-up process in international economics. Tanaka (2006) argues that imitation productivity enables developing countries to reduce the technology gap, asserting that when conditions are favourable, the imitation lag can be significantly shortened, although the timeframe is not precisely defined. This implies that the lag can be long if absorptive capacity is low. Similarly, Giachetti & Lanzolla (2016) add that the duration of this imitation lag can vary depending on factors such as the complexity of the technology, the level of absorptive capacity, and market conditions.

The discussion of the Imitation Lag hypothesis developed into the Product Cycle Theory (PCT). Vernon (1966) expanded on the Imitation Lag hypothesis by focusing on the life cycle of a particular 'new product' and its international trade impact, which was coined as the Product

Cycle Theory. The PCT examines how firms in the initial exporting country eventually import the product they innovated. The major contribution of this theory is that the imitation of new products may result in the initial exporter losing its competitive advantage to its trading partners. Some consumers from the initial exporting country may prefer the version of the imitating firms' products. Eventually, the exporting country becomes an importer of the commodity. Based on this view, some scholars (Udokporo, 2021; Osland,1991;1983) supported PCT's postulation. However, some criticised the theory for assuming that product ideas are not necessarily born in developed countries but everywhere where the activities of companies are. They claim that multinational firms establish research and development hubs in emerging markets, suggesting Reverse Innovation (Malodia *et al*., 2020; Von Zedtwitz *et al*., 2015; Ostraszewska & Tylec, 2015; Govindarajan & Euchner, 2012; Govindarajan & Ramamurti, 2011). The main opposition to the PCT is based on the product's origin, implying that the assertion of an initially importing country eventually becoming an exporter is not disputed. This provides the premise for this study to investigate why the pharmaceutical sector has not managed to imitate the imports either through the PCT or reverse innovation in the past two decades.

Over time, international trade literature shifted from the classical and neoclassical trade models, which focused on inter-industry trade[2], to the intra-industry trade (IIT), pioneered by Krugman (1981). Scholarly works over the years criticized the conventional comparative advantage and Heckscher-Ohlin theories for not adequately explaining trade among industrial countries. Three aspects of world trade contradict the classical theories. First, there is significant trade between countries endowed with similar factors of production. Second, a considerable part of trade consists of trade in similar goods, which displays an intra-industry character. Third, trade expansion in the post-war period has not led to significant changes in income distribution or reallocation of resources between industries (Krugman, 1981). These criticisms led to the development of empirical literature on intra-industry trade.

As the empirical literature on intra-industry trade developed, studies found that goods and services provided by firms in the same industry are differentiated. Grubel and Lloyd (1975), Balassa (1966), and Verdoorn (1960) performed unconventional empirical investigations to measure the magnitude and significance of intra-industry trade, their results confirmed that goods and services in the same industry are indeed differentiated. Likewise, the pharmaceutical

[2] Trade of goods or services between countries from different industries

sector's product range is highly differentiated, which provides the basis for measuring the level of intra-industry trade in pharmaceuticals.

Furthermore, intra-industry trade is associated with more trade benefits, and they can be summarized as follows. First, intra-industry trade benefits businesses and consumers through the increased product diversity within an industry (Dudovskiy, 2012). Second, intra-industry trade often conveys mutual brand recognition as an additional benefit not found in inter-industry trade (Peterson & Thies, 2012). Third, intra-industry trade allows firms to gain from dynamic economies of scale, stimulate innovation, and use their comparative advantages. Therefore, for it to be sustainable, countries need to identify their comparative advantage to continuously improve their production processes, upgrade technology, and enhance skills to stay competitive in a particular industry (Ruffin,1999; Dudovkiy, 2012). From this premise, research is needed to determine the comparative advantage of South African pharmaceutical firms so that more resources may be allocated to producing more competitive products. Identifying a comparative advantage helps the firms producing those products to strengthen their comparative advantage even further as the factors of production tend to gravitate towards segments of the economy that show a comparative advantage, which leads to growth in the industry. Furthermore, this study posits that intra-industry trade can benefit the pharmaceutical sector through joint research, technology, and information sharing, creating a conducive environment for countries or firms to improve their absorptive capacity.

Further development in intra-industry trade studies led to the emergence of the "New" New Trade Theory (NNTT) introduced by Melitz (2003). This theory is predicated on the understanding that companies operating within the same industry may have different abilities to withstand global competition, highlighting the diversity within sectors (Ottaviano, 2011). The NNTT changes the focus from a "sectoral view" of trade to one centered on the "firms' perspectives." According to the dynamic industry model, only the most productive firms are likely to enter the export market, while less productive firms focus on serving domestic consumers. Similarly, the South African pharmaceutical industry is characterized by a mix of firms with varying productivity levels. The market is oligopolistic, dominated by a few firms with substantial market power and high entry barriers, leading to an environment of imperfect competition. This structure results in a situation where only the most productive firms can compete domestically and internationally (Te Naudé & Luiz, 2013).

Melitz emphasizes the significance of export entry costs on trade outcomes, arguing that increased trade exposure reallocates resources towards more productive firms. Therefore, enhancing the national welfare and reducing import dependency in the South African pharmaceutical sector requires policies to reduce export entry costs, supporting less productive firms in improving efficiency.

While the NNTT emphasizes firm-level heterogeneity and the importance of productivity in accessing export markets, it should be noted that firms' ability to engage in international trade is not solely determined by structural market conditions but also by their internal capabilities to adapt external knowledge to improve production capacities. In South Africa, where global competitiveness is unevenly distributed across firms, improving absorptive capacity is critical in ensuring that companies integrate foreign knowledge and technologies to enhance productivity and participate in global value chains.

Absorptive capacity has been a subject of investigation in business research[3] and is defined by Cohen and Levinthal (1989) as the firm's ability to recognize, assimilate, and apply external knowledge for commercial purposes, which is crucial for promoting innovation and enhancing productivity. Absorptive capacity can improve productivity as firms adopt and adapt external knowledge and innovate (Harris & Yan, 2019; Roper *et al*., 2017; Tödtling & Trippl, 2011; Dahlander & Gann, 2010; Storper & Venables, 2004). The need to improve absorptive capacity in the South African pharmaceutical sector is a matter of urgency due to the industry's reliance on imported products and APIs (Council on Health Research for Development (COHRED) & New Partnership for Africa's Development (NEPAD), 2010). Innovation and investment in R&D are essential because firms that allocate resources to R&D are better positioned to understand and implement external innovations. However, the South African pharmaceutical sector has historically shown low levels of R&D investment, which hampers the development of new products and the enhancement of existing processes (COHRED & NEPAD, 2010). Understanding how firms acquire and exploit external knowledge is imperative for policymakers to identify areas that need intervention to improve productivity that leads to growth in the sector (Roper *et al*., 2017).

[3] Darwish *et al.*, 2020; Müller *et al*., 2020; Strøm-Andersen, 2020; Limaj & Bernroider, 2019; Gkypali *et al*., 2018; Najafi-Tavani *et al.*, 2018; Zou *et al*., 2018; Enkel *et al.*, 2017; Imbriani *et al.*, 2014; Qian & Acs, 2013

1.2 Problem Statement

South Africa's pharmaceutical sector is well-developed, and South Africa is the only country in the SADC region that complies with the good manufacturing practice standards of the World Health Organisation (WHO) (Department of Trade and Industry, 2020). Despite the capacity to produce a wide range of pharmaceuticals, local manufacturers rely heavily on APIs imports. Various finished pharmaceutical products are also imported, as local manufacturers cannot compete on price (Veitch, 2020). Viviers *et al.* (2014), Te Naudé and Luiz (2013), and Maloney and Segal (2007) have consistently highlighted this persistent import dependence.

The increasing demand for generic medicine and APIs imports in South Africa, coupled with the fact that China and India dominate the world's pharmaceutical supply at a combined 31% of registered Food and Drug Administration (FDA) products, raises concerns about the risk riding on just a few countries controlling the world's pharmaceutical supplies (American Affairs, 2024; United States FDA, 2019). Dependence on imports makes South Africa's pharmaceutical sector vulnerable to external shocks and geopolitical shifts. The COVID-19 pandemic demonstrated how a global crisis can disrupt supply chains, resulting in shortages of essential products. In such crisis situations, companies with significant market power may inflate prices, making critical medications unaffordable (Boshoff, 2020). Additionally, reliance on imports creates uncertainty during turbulent political regimes and rising economic nationalism. For instance, during the Trump administration, the United States adopted a more protectionist stance, prioritizing domestic production of essential goods, including pharmaceuticals, through policies such as the "Buy American" executive order (Trump, 2020; Evenett & Fritz, 2020). This kind of political shift highlights the potential for sudden policy changes in major exporting countries to disrupt global access to critical health products. Protectionist policies not only limit the availability of imported pharmaceuticals but also create uncertainty in global markets, further deepening the risk for import-dependent countries like South Africa.

Considering that the pharmaceutical sector plays a crucial role in public welfare, industrial development, and technological advancement (Danzon & Towse, 2014), reducing dependence on external supplies is crucial. This highlights the need to strengthen internal capabilities, such as absorptive capacity, to enable the sector to better acquire, assimilate, and apply external knowledge for improved local production and competitiveness. Existing research in the South African pharmaceutical trade has primarily concentrated on structural trade patterns and

macroeconomic constraints, often overlooking the crucial aspects of firm-level learning and innovation capabilities (Viviers *et al.,* 2014; Te Naudé & Luiz, 2013; Maloney & Segal, 2007). Consequently, the influence of absorptive capacity on the sector's ability to acquire, assimilate, transform, and exploit external knowledge remains underexplored. This gap is significant, as absorptive capacity is increasingly recognized as a vital driver of competitiveness in knowledge-intensive industries. In light of global supply chain disruptions, such as those caused by the COVID-19 pandemic, the resilience of the pharmaceutical industry hinges not only on physical infrastructure but also on the regulatory environment. However, there is a lack of empirical research examining how absorptive capacity affects South Africa's pharmaceutical sector's participation in intra-industry trade and its ability to mitigate vulnerability to global disruptions.

1.3 Objectives of the Research

Considering the theoretical framework, empirical evidence, and context, the primary goal of this study is to measure the relationship between absorptive capacity, Growth, and Intra-Industry Trade in the pharmaceutical sector of South Africa. The main goal is broken down into the following subgoals:

1.3.1 To measure intra-industry trade in the South African pharmaceutical sector and identify a key factor to improving it.

1.3.2 To determine the comparative advantage in the South African pharmaceutical sector.

1.3.3 To identify key determinants of absorptive capacity in the South African pharmaceutical sector to arrive at the most appropriate measurement of absorptive capacity.

1.3.4 Establishing the relationship between intra-industry trade and absorptive capacity.

1.3.5 To examine the effect of absorptive capacity and intra-industry trade on South African pharmaceutical industry growth.

1.4 Research Questions

In order to achieve the outlined objectives, the study seeks to address the following questions:

(a) What is the level of intra-industry trade in the South African pharmaceutical sector?

(b) Which products do the South African pharmaceutical sector have a comparative advantage in producing?

(c) What factors determine the absorptive capacity in the South African pharmaceutical sector?

(d) To what extent does intra-industry trade affect absorptive capacity in the South African Pharmaceutical sector?

(e) Is there a mediation role played by absorptive capacity on the effect of intra-industry trade on growth?

1.5 Research Hypothesis

Based on the theoretical connections between absorptive capacity, intra-industry trade, and Growth, the following hypothesis was developed to achieve the study's objectives.

H_0: The impact of intra-industry trade on the growth of the South African pharmaceutical sector is not mediated by absorptive capacity.

H_1: The impact of intra-industry trade on the growth of the South African pharmaceutical sector is mediated by absorptive capacity.

1.6 Justification of the study

Absorptive capacity has emerged as a vital concept in business and innovation research (Harris & Yan, 2019), yet its application in international trade within the context of developing economies remains underexplored. In South Africa's pharmaceutical sector, which plays a critical role in public health and economic development, there is a notable gap in the empirical literature regarding the relationship between absorptive capacity and intra-industry trade. This study addresses that gap by investigating how intra-industry trade can facilitate the acquisition, assimilation, transformation, and exploitation of external knowledge, enhancing absorptive capacity and stimulating growth in the pharmaceutical sector.

Despite various studies analysing South Africa's pharmaceutical industry, limited empirical attention has been paid to the reasons behind the country's continued reliance on imports of Active Pharmaceutical Ingredients (APIs) and generic medicines for the past two decades (Veitch, 2020; Wouters *et al*.,2019; Viviers *et al*., 2014; Fatti & du Toit, 2013; Te Naudé & Luiz, 2013; Maloney & Segal, 2007). This study posits that intra-industry trade serves as a channel for knowledge transfer, technology spillover, and benchmarking of best practices, all of which are essential for strengthening absorptive capacity. Improved absorptive capacity, in turn, supports the localization of production processes, the enhancement of product quality, and the promotion of innovation-driven industrial growth.

Therefore, the significance of this research lies in its potential to identify the determinants of absorptive capacity and reveal the constraints that hinder its core dimensions. By doing so, the study provides insights into how South Africa can reduce its import dependency, improve its manufacturing capabilities, and strengthen its position in the global pharmaceutical value chain. The ability to absorb foreign knowledge rests on how much countries invest in their capacity to innovate (Cohen & Levinthal, 1989). If firms adopt and exploit new knowledge from external sources, industrial strategies to boost productivity will be more effective (Harris & Yan, 2019). This is especially relevant in the post-pandemic context, where the need for self-reliance in pharmaceutical production has become a strategic imperative across the African continent.

To this end, this study intends to contribute to three spheres of literature. First, it expands empirical literature by focusing on intra-industry trade and absorptive capacity in a developing country in Africa, which has been largely neglected. Second, it contributes to the methodology by measuring intra-industry trade as a fundamental driver of absorptive capacity, an approach that moves beyond the traditional focus on foreign direct investment (FDI) as the main external knowledge source. Most studies have focused on the relationship between absorptive capacity and FDI (Kinoshita & Lu, 2006; Krogstrup & Matar, 2005; Castellani & Zanfei, 2003; Durham, 2004), and they are almost two decades old. Third, the study develops a more comprehensive quantitative measure of absorptive capacity, integrating all four dimensions, incorporating acquisition, assimilation, transformation, and exploitation, unlike many previous studies that capture only selected aspects.

Furthermore, this study aligns with the goals of the 15-Year Pharmaceutical Manufacturing Plan for Africa (PMPA) 2013-2028 and Sustainable Development Goal 17 (SDG 17) 2030. The PMPA focuses on boosting local pharmaceutical manufacturing and improving access to affordable medicines, while the SDG aims to increase global exports from developing countries to enhance resilience against economic shocks (UNDP, 2020; AUC-UNIDO, 2012). This study also supports the broader vision of Africa's Agenda 2063, which emphasises inclusive growth, industrial development, and self-reliance in strategic sectors such as healthcare and pharmaceuticals, by promoting regional value chains, enhancing intra-African trade, and reducing dependence on external aid (AUC, 2015).

The findings of this research are expected to inform policymakers, industry stakeholders, and development agencies seeking to promote innovation, improve resource allocation, and enhance the competitiveness and sustainability of the pharmaceutical sector in South Africa.

Ultimately, the study contributes to broader efforts aimed at promoting inclusive industrial development, reducing vulnerabilities in the health sector, and supporting regional pharmaceutical integration in Southern Africa.

1.7 Overview of the methodological approach

The research design of this study follows a positivist approach, a paradigm that requires gathering data and specifying models to examine a phenomenon through the lens of empirical evidence and systematic analysis (Caldwell, 1980). This involves developing models representing the underlying structures and patterns of the situation under investigation using data. Due to the nature of the study, three empirical approaches have been used to determine intra-industry trade, comparative advantage, and absorptive capacity.

Achieving the first objective requires an examination of the intra-industry trade and identifying the key variable in improving it. In examining intra-industry trade in the South African pharmaceutical sector, the study will use 1-digit Standard International Trade Classification (SITC) data from the United Nations Conference on Trade and Development (UNCTAD) databases, covering 2002–2021. The Grubel-Lloyd Index (GLI) is traditionally used to measure IIT between countries. However, it has limitations concerning theoretical foundations and neglects the adjustment costs involved in trade (Lee, 2004). In response to these limitations, the Marginal Intra-Industry Trade (MIIT) index, proposed by Brülhart (1994), offers a more nuanced perspective by capturing adjustments in intra- and inter-industry trade patterns. This study employs the MIIT index and Unmatched Changes in Trade to capture trade patterns in the sector.

To identify the key factor in boosting intra-industry trade in the pharmaceutical sector, the study builds on the theoretical framework that links firm productivity trade outcomes found in the works of Ricci & Trionfetti (2012); Aitken *et al*. (1997); Roberts & Tybout (1997); Bernard & Jensen (2004). The study asserts that increases in productivity lead to higher exports and more matched trade, whereas declines in productivity result in decreased exports and unmatched trade. As such, the Malmquist index is used to quantify the shifts in Total Factor Productivity (TFP) using data from the South African Reserve Bank covering the period 2001-2021. The index compares TFP changes between consecutive periods while accounting for any shifts in the typical production technology (Balk, 2013; Coelli *et al*., 2005). This framework assesses how efficiently pharmaceutical manufacturing firms utilise their resources and how their

productivity evolves. The Data Envelopment Analysis (DEA) has been widely used in the studies of productivity and efficiency studies to analyse changes in Total Factor Productivity. The DEA determines efficient levels of inputs and outputs for the organisation under evaluation by computing a scalar measure of efficiency. This study used the Malmquist Total Factor Productivity (MTFP) index to examine the factors that influence TFP changes in the pharmaceutical industry because it allows us to assess how efficiency and production technology evolve. As such, the Unmatched Changes in Trade (UMCIT) is used as an output variable to measure productivity changes, while Research and Development (R&D), Foreign Direct Investment (FDI), real capital formation, and labour serve as input variables. R&D, in particular, is emphasized for its role in fostering innovation, enhancing firm capabilities, and driving long-term productivity gains, despite its associated challenges (Blanco & Prieger, 2016; Miguel Benavente, 2006; Griliches, 1998).

To address the second subgoal, the study uses trade data for pharmaceutical products disaggregated at the HS 4-digit level for 2002–2021, sourced from the Trade Map database. The Normalized Revealed Comparative Advantage (NRCA) index is employed to identify products produced more efficiently within the South African pharmaceutical sector relative to its selected trading partners. Additionally, the Trade Complementarity Index (TCI) is calculated for 2022–2023 to assess how South Africa's pharmaceutical trade currently aligns with its trading partners, with the main focus on African countries after the height of COVID-19. The selected trading partners include six African, three emerging, and eight developed economies. The justification for the selected countries is provided in Chapter 6, which deals with this objective.

Lastly, the study addresses its core objectives, which are to (i) identify the determinants of absorptive capacity in the South African pharmaceutical industry, (ii) establish the relationship between IIT and absorptive capacity, and (iii) examine the effect of absorptive capacity and IIT on the sector's growth using the Structural Equation Model (SEM). The variables used in the analysis are Research and Development (R&D), Foreign Direct Investment (FDI), Human Development Index (HDI), Level of Trade Barriers, Patent Applications, Exported Growth, Intra-Industry Trade, Capital and Labour ratio, and the quality of institutions (QI). These variables were further clustered to construct all four aspects of absorptive capacity in the South African pharmaceutical sector. Exported Growth is a proxy for growth in the pharmaceutical sector. These variables are further clustered into the four factors of absorptive capacity, namely,

acquisition, assimilation, transformation, and exploitation. The study used the SEM to benefit from its Partial Least Squares (PLS-SEM) feature, suitable for handling complex models. The SEM also includes factor analysis and a mediation model, utilizing data from the South African Reserve Bank (SARB) and World Development Indicators (WDI) for 2001–2021. This comprehensive approach used in this study provides a multidimensional understanding of the factors shaping South Africa's pharmaceutical trade and its absorptive capacity. Further details about the SEM model are provided in Chapter Seven, which discusses the SEM approach.

1.8 Thesis and Structure

The rest of the thesis will be structured as follows:

Chapter 2: The South African Pharmaceutical Sector. This chapter provides an overview of the South African pharmaceutical sector, highlighting its structure, economic contribution, and strategic importance to public health. It traces the sector's historical development, outlines key regulatory frameworks, and examines its integration into global and regional trade networks. This chapter also highlights the challenges facing the industry and opportunities to explore.

Chapter 3: Literature Review. This chapter unpacks the development of theoretical and empirical literature on international trade, providing the framework that underpins the analysis of intra-industry trade in the South African pharmaceutical sector. The discussion also explores the interplay between absorptive capacity, intra-industry trade, and the growth of the sector.

Chapter 4: Examining trends in key determinants of Absorptive Capacity. This chapter examines the trends of variables identified from the literature as key determinants of absorptive capacity. It shows how the variables contribute to absorptive capacity and examines each variable, unearthing the possible underlying causes for the observed trend.

Chapter 5: Measuring Intra-Industry Trade and Productivity in the South African Pharmaceutical Sector: Implication for Import Dependence[4]. This chapter examines the trade pattern in the pharmaceutical industry and measures the level of intra-industry trade. Subsequently, the chapter measures productivity in the South African pharmaceutical sector as a key factor in improving intra-industry trade.

[4] A condensed version of this chapter was published as an original research article by the South African Journal of Economic and Management Sciences (SAJEMS) on 05 August 2024. Available online at https://sajems.org/index.php/sajems/article/view/5486

Chapter 6: Estimating Comparative Advantage in the Pharmaceutical Sector[5]. This chapter examines the comparative advantage in pharmaceutical trade between South Africa and its selected trading partners, aiming to capture its pattern over the past two decades. Subsequently, the chapter measures the trade complementarity between South Africa and its trading partners to determine how well South Africa's pharmaceutical export profile matches other countries' import profiles. This approach helps to evaluate how well two countries' trade structures complement each other.

Chapter 7: Determinants of Absorptive Capacity and its Impact on Intra-Industry Trade and Growth in South Africa's Pharmaceutical Sector. This chapter discusses the empirical methodology adopted to (i) Identify the determinants of absorptive capacity in the South African pharmaceutical industry, (ii) Establish the effect of absorptive capacity on intra-industry trade, and (iii) determine how absorptive capacity and intra-industry trade impact the growth of the South African pharmaceutical sector. The chapter further discusses the results of the PLS-SEM model employed to determine the determinants of absorptive capacity and establish the interplay between absorptive capacity, intra-industry trade, and growth in the South African pharmaceutical sector.

Chapter 8: Policy Implications, Recommendations, and Conclusion. This chapter recaps the thesis objectives and summarizes the findings and their implications. The limitations and possible areas of further research are identified. The chapter also makes recommendations based on the findings and provides a conclusion.

[5] A condensed version of this chapter is under consideration by Economic Research Southern Africa (ERSA) for a working paper series.

Chapter 2
The South African Pharmaceutical Sector

2.1 Introduction

The pharmaceutical sector is a crucial element of South Africa's economy, and has a significant impact on growth and development. This chapter provides an in-depth overview of this sector, covering its size, key players, trade dynamics, regulatory frameworks, pricing, and the challenges and opportunities that influence its trajectory. As the chapter explores the South African pharmaceutical sector, it focuses on its trade dynamics as a means of exposure to external knowledge, which should be absorbed and internalized. This highlights the importance of firms' absorptive capacity, or ability to acquire, assimilate, transform, and exploit external knowledge gained from international trade. Analyzing absorptive capacity within the pharmaceutical context provides a better understanding of how firms effectively integrate and adapt external knowledge and technologies to position themselves competitively in the global market.

According to the African Pharmaceutical Analysis Report (2021), South Africa is one of Africa's largest and most advanced pharmaceutical producers, boasting an estimated market size of $3.9 billion. Egypt follows with a market size of $2.6 billion. The industry comprises local and international companies that manufacture and distribute pharmaceutical products. Among the major players are Aspen Pharmacare, which supplies to over 150 countries, and Adcock Ingram, with a market share of 18% by value and 27% by volume (Veitch, 2020). Figure 1 below shows that Adcock Ingram has the biggest market share in Africa (12.10%), closely followed by Novartis (11.50 %) share of key pharmaceutical companies operating in South Africa.

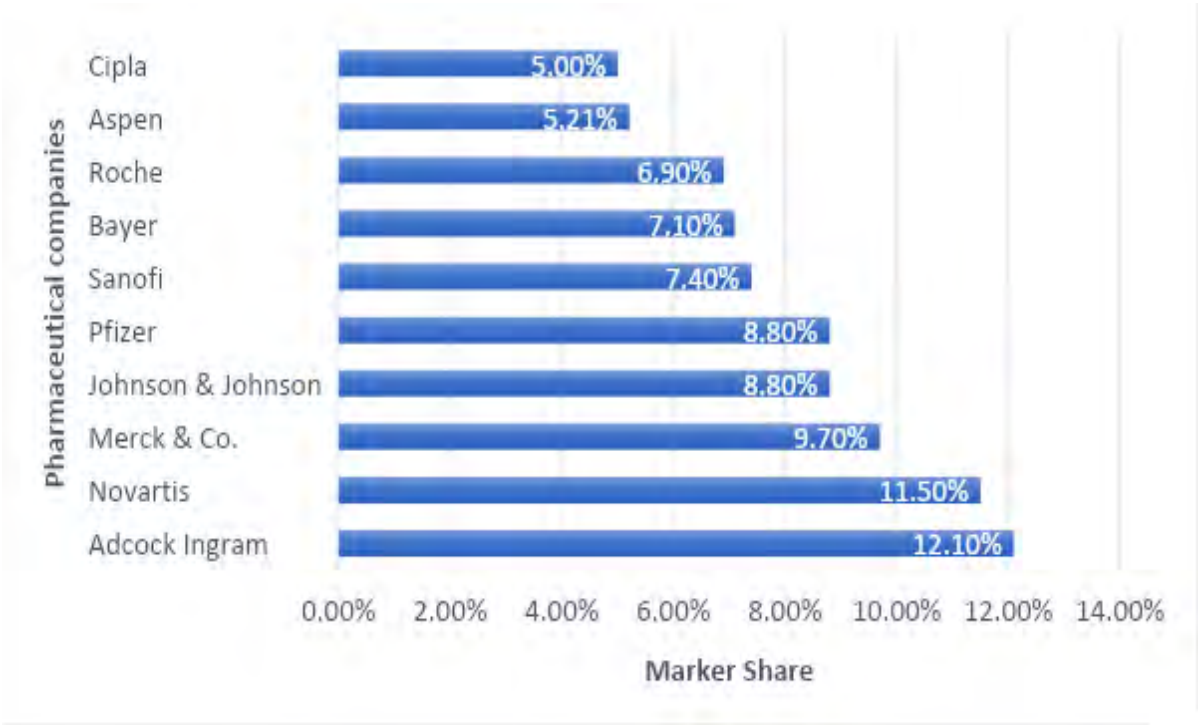

Figure 1. Key players by African market share 2021 Source: African Pharmaceutical Analysis Report (2021)

Pharmaceutical companies are essential in the pharmaceutical supply chain, including Research and Development, manufacturing, marketing, and distribution. Their dedicated research efforts lead to the development of innovative medicines and therapies that effectively tackle pressing medical needs, promoting significant advancements in healthcare. Additionally, their manufacturing capabilities ensure a consistent supply of vital medications, supporting healthcare providers and patients.

As such, Figure 2 and Table 1 below illustrate the diverse range of companies operating at various stages of the pharmaceutical value chain in South Africa and their dominance in the distribution of prescription and non-prescription medication.

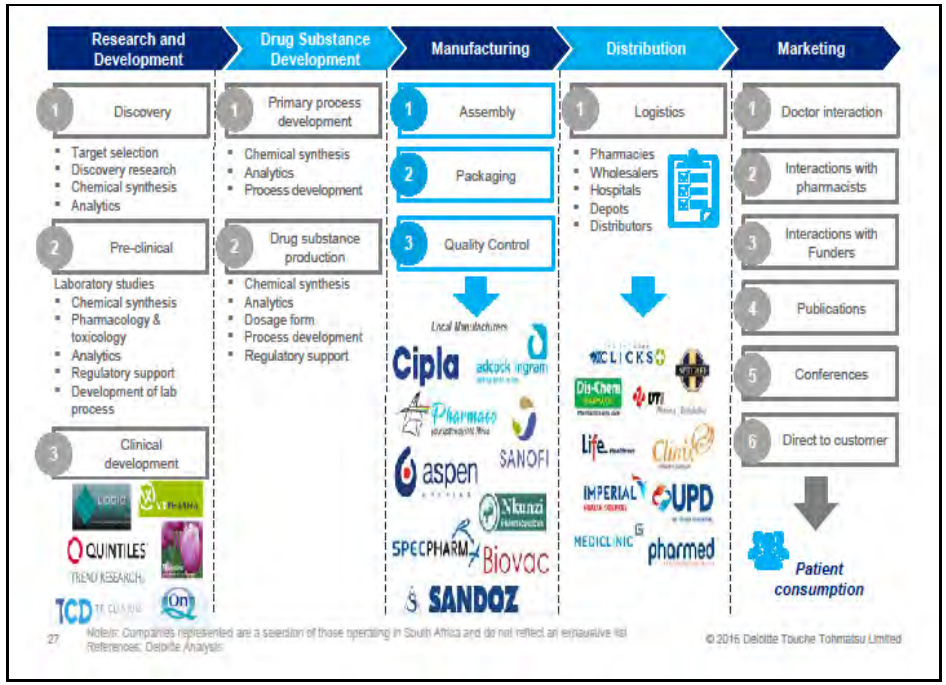

Figure 1: Companies in the South African pharmaceutical value chain
Source: Department of Trade and Industry (2017)

Table 1: Pharmaceutical Market Leaders

Rank	Overall	Rx	OTC	Non-Schedule	State
	All schedules	Schedule3 and above	Schedule 1&2 only	Scheduling not applicable	All schedules
1	ASPEN*	ASPEN*	ADCOCK INGRAM*	ADCOCK INGRAM*	MYLAN
2	ADCOCK INGRAM*	SANOFI	ASPEN*	ASCENDIS*	SANOFI
3	CIPLA	NOVARTIS	CIPLA	CIPLA	ASPEN*
4	SANOFI	CIPLA	JOHNSON &JOHNSON (Consumer)	ASPEN*	ADCOCK INGRAM*
5	NOVARTIS	ADCOCK INGRAM*	INOVA PHARMA	ABBOTT	PFIZER
Total	722	144	95	647	371

Sources: Adcock Ingram, Iqvia (2020) cited in (Veitch, 2020)
* Denotes local companies, Rx= Prescription medication, OTC = Over-the-counter medicines

Table 1 shows that Aspen plays a major role in providing prescription and non-scheduled medications, while Adcock Ingram holds a significant market share in providing over-the-counter drugs and state-specific sales. Other prominent companies like Cipla, Sanofi, and Novartis also feature prominently across different categories, demonstrating a diverse environment of pharmaceutical companies in the market.

It is also evident from Table 1 that the South African pharmaceutical sector is predominantly shaped by multinational corporations with substantial influence and market presence. Research shows that the majority of R&D spending comes from the field of medical and health sciences amounting to R7.404 billion or 22.1% of the total expenditure. Of the R7.404 billion, about R2.95 billion (constituting about 40%) was expected to be spent by innovative multinational (MNCs) companies between 2016 and 2021, supporting clinical research into new treatments serving unmet medical needs (IPASA, 2019). This showed the significant role played by multinational companies in the South African economy by substantially contributing to research and development, clinical research, job creation, and manufacturing. The substantial spending on clinical research puts South Africa ahead of its developing counterparts. Nevertheless, the country still lags behind developed countries, especially in HIV/AIDS clinical trials, where it falls significantly short compared to countries like the United Kingdom, which has more than six times the number of trials per capita (IPASA, 2019; Montague & Oosthuizen, 2010).

It is worth noting that the South African pharmaceutical sector has undergone significant changes in recent years. Multinational corporations (MNCs) have slowly decreased their presence in the industry, which has resulted in a shift in manufacturing structure. This trend results from globalization and national factors affecting the industry. Many MNC manufacturers have scaled back their production presence, leaving only a few smaller local producers specializing in producing lower volumes of products intended for small, niche markets. Table 2 provides a list of pharmaceutical plant closures in the late 1990s.

Table 2: Closures of domestic pharmaceutical plants in South Africa in the late 1990s

Company	**Location**	**Job Losses**	**Reason**
Searl	Johannesburg	77	Restructuring post-Monsanto merger
Pharmacial/Upjohn	Isando	75	Merger between Pharmacia &Upjohn
Bristol Myers Squibb	Wadeville	50	Merger between Bristol-Myers & Squibb
Wellcome	Spartan	150	Restructuring-merger with Glaxo
Adcock Ingram	Various	1000	Merger with Prempharm
Boots	Isando	Unknown	Company bought out by Knoll

Source: Horner (2021)

In light of Table 2 above, it is important for the South African companies involved in pharmaceutical manufacturing to reassess the industry and identify opportunities presented by the closure of some firms. The government should play a crucial role in shaping the sector's future trajectory, particularly in incentivizing investment in advanced manufacturing capabilities and promoting access to affordable healthcare solutions for the population. It is critical for the South African pharmaceutical industry to effectively enhance its strengths in research and development while addressing challenges related to market access, intellectual property rights, technological advancements, and infrastructure.

2.2 A Brief Historical Analysis of Regulatory Development in South Africa's Pharmaceutical Industry

The Medicines and Related Substances Control Act of 1965 regulated the use of medicines in South Africa and underwent revisions in 1997 to establish the Medicines Control Council (MCC) as a legal entity. The MCC implemented faster registration processes and introduced Section 15C, which allowed for compulsory licenses for medicines. A legal challenge by the Pharmaceutical Manufacturers' Association (PMA) and its members in 1998 led to the proposal to replace MCC with the South African Medicines and Medical Devices Regulatory Authority (SAMMDRA), which the Constitutional Court ultimately overturned. An Amendment Act was passed in 2002, repealing the SAMMDRA Act. In 2008 and 2015, subsequent Amendment Acts replaced the MCC with the South African Health Products Regulatory Authority (SAHPRA), strengthening regulatory frameworks within the pharmaceutical and healthcare sector. SAHPRA plays a crucial role in evaluating and approving medicines and healthcare products in the country, ensuring they meet rigorous safety and quality standards without compromise. As such, the SAHPRA has recalled a number of medicines from May 2021 to August 2023 (Table 3, Appendix A).

In addition to SAHPRA, regulatory bodies like the South African National Accreditation System (SANAS) and the South African Bureau of Standards (SABS) play a crucial role in certifying and accrediting healthcare facilities, products, and services. These entities enforce technical standards and ensure that international norms, such as the Trade-Related Aspects of Intellectual Property Rights (TRIPS) Agreement established by the World Trade Organisation (WTO), are met. For pharmaceutical companies, complying with European Union (EU) Good Distribution Practices is imperative to maintain superior quality standards in the distribution of medications. In 1993, during the apartheid era, the Department of National Health and

Population Development formulated a National Pharmaceutical Policy for South Africa as there were concerns over medicine policy. These concerns involved the overuse of branded medications compared to generic options, a comprehensive national medicine policy was not established, nor were any regulatory modifications made including, the permission for pharmacists to substitute generic drugs (Gray *et al*., 2017).

Legislative frameworks, such as Section 15 of the Medicines and Related Substances Amendment Act, grant powers to the Department of Health (DOH) minister to set registration periods for complementary medicines imported without the patent holder's consent. This provision balances intellectual property rights with public health interests, encouraging fair competition while preserving innovation (Gray *et al*., 2017). However, despite the broader regulatory framework, challenges persist, including the delayed implementation of the draft charter for the health industry, which was released in 2005 but has yet to fully materialize. The delay is because of systematic challenges like fragmentation of services, which leaves the South African healthcare system fragmented, a legacy of apartheid, which complicates the integration of public and private sectors (London Politica, 2022). Moreover, there are governance and trust issues like implementation gaps and trust deficits. These manifest in a notable gap between policy formulation and execution, with the government struggling to translate well-defined policies into effective practice, and the public trust in the government's ability to manage health reforms effectively is low, particularly in light of a robust private healthcare sector (London Politica, 2022).

2.3 Medicine Pricing in South Africa

Ten years since the formulation of the National Pharmaceutical Policy, the Department of Health made strides to promote transparency and accountability in the healthcare industry by implementing the Single Exit Price (SEP) framework in August 2004. The SEP is a pricing mechanism the standardized the cost of medicines across suppliers and eliminated discounts and bonuses, creating a more transparent and competitive environment. The introduction of SEP indicated commitment of the South African government in improving healthcare affordability in South Africa, as outlined in the Medicines and Related Substances Control Amendment Act of 1997 (Taylor, 2007). The SEP policy had a substantial and sustained impact, with immediate and long-term price reductions for generics, encouraging broader uptake and accessibility (Moodley *et al*., 2019). The transparency of pricing in healthcare is understood to

be an easily accessible source of information for health services, which helps determine the value of those services and allows patients and other care purchasers to make decisions about the level of prices they are willing to pay (HFMA, 2014).

Despite the good intentions of implementing SEP, the rise of pseudo-generics branded generics introduced by originator companies has complicated the pharmaceutical pricing environment, as they often remain more expensive than true generics, potentially misleading consumers and undermining cost-saving goals (Bangalee & Suleman, 2019). Furthermore, the South African National Drug Policy aimed to promote rational medicine use (RMU), yet recent studies indicate persistent gaps in achieving optimal generic prescribing. In Limpopo province, for instance, generic prescribing rates remain low (43%) and significantly trail behind WHO benchmarks and peer nations like Ethiopia and Eritrea, where rates exceed 90% (Akunne *et al*., 2023). Public trust and awareness also play a crucial role, as brand knowledge and perceptions of efficacy greatly influence young adults' acceptance and purchase of generics (Duh & Diniso, 2020). Therefore, while policy has laid foundational infrastructure for generic medicine adoption in South Africa, consistent implementation, public education, and vigilant regulation are necessary to maximize its impact.

Furthermore, achieving SEP goals in the pharmaceutical sector requires collaboration from industry players, policymakers, healthcare providers, insurance companies, and payers to avoid unintended consequences that undermine the initiative to improve affordability to good quality medication throuth transparent pricing (HFMA, 2014). More so in South Africa, where pharmaceutical manufacturerers mostly depend on imported APIs. For instance, pharmaceutical manufacturers called for an increase in prices in response to an increase in inflation and a weaker Rand. These increases have led to higher production costs and reduced competitiveness, resulting in declining local production and the closure of some community pharmacies (PMG, 2017; Ngozwana, 2016). Furthermore, a report compiled by the Helen Suzman Foundation (HSF) on the ability of South Africa to implement the World Health Organisation (WHO) pricing guidelines revealed that South Africa needs a mechanism to monitor the actual prices charged in the pharmaceutical sector (HSF, 2015). As such, consumers continue to face gradual increases in medication prices, as depicted in Figure 3.

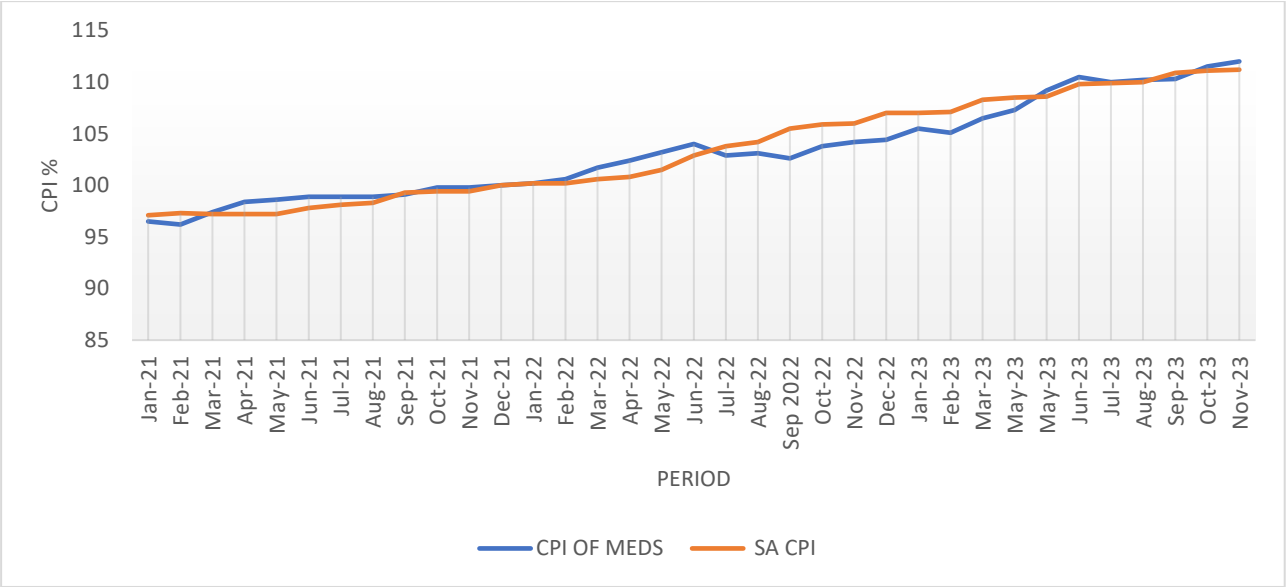

Figure 3: The South African and medical product Consumer price index (CPI) from Jan 2021 to Nov 2023

Source: Author's compilation using data from Statistica (2023)

Figure 3 shows the periods where medicinal product prices have increased faster than the broader basket of goods and services. This increase is mostly notable during periods March to August 2021 and February to May 2022. The same pattern is repeated from October to November 2023. Both indices show a steady upward trend, likely due to the effect of COVID-19. This trend threatens affordability and access to healthcare, as rising pharmaceutical costs may cause financial strain to households. While the SEP may have been successfully implemented in South Africa, research suggests that it lacks transparency and economic feasibility (Te Naudé & Luiz, 2013; Maloney & Segal, 2007). Furthermore, simply regulating domestic prices in an industry that heavily relies on imported inputs is insufficient to achieve the affordability of pharmaceutical supplies. Therefore, the next section interrogates trade in the South African pharmaceutical sector.

2.4 Trade in the South African pharmaceutical sector

International trade plays an important role in the South African pharmaceutical sector as the country largely imports inputs while simultaneously exporting pharmaceutical products to other African countries. The main export markets for South African pharmaceuticals include Zimbabwe, Mozambique, and Namibia. Some South African pharmaceutical companies have a strong presence in both emerging and developed countries (Trading Economics, 2023a; Trading Economics, 2023b; Goldstein Research, 2021; FurtherAfrica, 2024). However, most of these exports are produced by multinational companies operating in South Africa.

Considering imports, the South African pharmaceutical industry has focused on manufacturing drugs from imported active and inactive ingredients, mainly sourced from international markets such as the United States of America, Europe, and Asia (Horner, 2021). According to Veitch (2020), while almost 70% of pharmaceutical products consumed in South Africa are produced locally, various active ingredients and finished products have been imported, an observation also shared by Rayment (2020). Active Pharmaceutical Ingredients account for between 60%-80% of the cost of production. Currently, India and China are global leaders in manufacturing APIs and related intermediates, and South Africa imports approximately R15 billion worth of APIs annually (DTI, 2024). Excessive demand for pharmaceutical imports contributes to the country's trade deficit. Table 4 below shows the pattern of trade in South Africa's pharmaceutical industry in the past two decades.

Table 4: South Africa's world trade in pharmaceuticals and % exports to SADC. Unit: US$ thousand

Year	Imports in USD from ROW	Exports in USD to ROW	Pharmaceutical Trade balance	% Share of pharm exports on total exports	%Share of pharm import on total imports	% Share of SA's pharm exports to SADC
2002	587852	83617	-504235	0.36	2.55	27,6
2003	772241	89387	-682854	0.28	2.44	27.71
2004	961415	108455	-852960	0.27	2.39	33.58
2005	1168572	120531	-1048041	0.26	2.49	28.95
2006	1330743	120093	-1210650	0.23	2.53	26.41
2007	1475429	142396	-1333033	0.22	2.3	28.76
2008	1569555	177867	-1391688	0.24	2.12	33.76
2009	1588134	178183	-1409951	0.33	2.95	37.19
2010	2074511	386809	-1687702	0.47	2.51	73.24
2011	2202356	462183	-1740173	0.43	2.04	73.69
2012	2366798	431673	-1935125	0.44	2.39	68.42
2013	2272462	432720	-1839742	0.46	2.39	65.86
2014	2068704	429570	-1639134	0.46	2.23	63.85
2015	2178581	402472	-1776109	0.5	2.71	63.89
2016	1893409	420409	-1473000	0.55	2.49	54.57
2017	2238147	450912	-1787235	0.51	2.54	61.54
2018	2501754	429299	-2072455	0.46	2.67	67.78
2019	2421100	434067	-1987033	0.49	2.71	62.28
2020	2401518	392121	-2009397	0.46	2.82	59.36
2021	3065610	894213	-2171397	0.72	3.27	30.98
2022	2535502	724883	-1810619	0.58	2.27	37.95
2023	2424694	450269	-1974425	0.41	2.26	59.85

Note: ROW- Rest of the World
Source: Author's own computation using data from Trademap (2020).

Table 4 above depicts that pharmaceutical imports are high and increasing while exports remain low, resulting in a consistent deficit, with the highest deficit in 2021, likely due to the impact

of COVID-19. There is an overall increase in the share of exports on total exports. The SADC region accounts for a significant percentage of South Africa's pharmaceutical exports, with the highest percentage of over 70% in 2010 and 2011, followed by a general decline to lower percentages but still significant at around 59.85% in 2023. The FIFA World Cup 2010 hosted by South Africa likely impacted South Africa's economic activities, including pharmaceutical exports (Niyimbanira & Surujlal, 2011). The presence of the international audience and increased healthcare demands could have boosted the SADC. Another factor that potentially contributed to the spike in pharmaceutical exports in 2011 was the expiration of the patent for the cholesterol-lowering drug Lipitor in 2011, which led to a rapid decrease in its market share as cheaper generics entered the market (Cruz, 2024). Table 4 shows how global events can impact and shape trade in the South African pharmaceutical sector.

2.5 Challenges and opportunities in the South African pharmaceutical sector

In recent years, the South African pharmaceutical sector has had many challenges and opportunities. From the accessibility and affordability of essential medications, especially in the public sector, where budget constraints and supply chain disruptions have hindered consistent medication availability (Hanefeld *et al*., 2024). Additionally, the industry faces intense global competition, regulatory changes, and infrastructure gaps, which cause significant supply chain disruptions. However, these challenges are met with notable opportunities created by implementing the AfCFTA, which promises market expansion and regulatory harmonization (Nqeketo & Sagandira, 2024). Moreover, advancements in technology and the push for local manufacturing, exemplified by initiatives like Aspen Pharmacare's licensing agreement to produce its own COVID-19 vaccine, indicate a sector poised for growth and innovation. This section discusses the key challenges facing the South African pharmaceutical industry, the opportunities for growth and development, and potential strategies to exploit those opportunities.

One of the challenges facing the global pharmaceutical industry is the growing presence of counterfeit products. At least 1 in 10 medicines in low- and middle-income countries are substandard or falsified (WHO, 2025). While everyone is at risk, populations from countries with weaker health systems and countries with a disrupted supply chain are more vulnerable to falsified products. Counterfeit products are also prevalent in South Africa and are difficult to detect as they can enter the supply chain at any manufacturing stage, from processing to

distribution (Moshoeshoe *et al*., 2022; Schneider & Nam, 2020). These substandard products are often sold online and in informal markets at a lower price than legitimate medicinal products, which attracts consumers who seek cheaper alternatives. This undermines legitimate business and contributes to unemployment (Thenga, 2021). Thus, the pharmaceutical sector is highly regulated, and there is strict control on the sale of pharmaceuticals. As such, the pharmaceutical products are subject to strict government regulations and must meet South African quality and safety standards. Despite regulatory efforts, the existence of counterfeit products continues to be a significant threat.

Other challenges that the South African pharmaceutical industry is grappling with, as pointed out by Rayment (2020), include a shortage of the necessary skill set within the Medicines Control sector, lengthy registration periods through the Medicine Control Council (MCC), and prolonged approval processes for clinical trials. For instance, between 2011 and 2017, the MCC process had the longest average approval time of 2092 calendar days (almost 69 months), but the introduction of the risk-based assessment (RBA) process reduced it to 511 calendar days (almost 17months) (Moeti *et al*., 2023). Although the RBA process significantly reduced the average approval time, South Africa is still trailing behind its peers like China, India, and Brazil, which have relatively shorter timelines. Approval time in China takes 15.4 months, whereas India and Brazil take 12-18 months (Su *et al*., 2022; Jawahar & Lakshmi, 2017). Europe maintains a swift process with a standard approval period of 12 months (Jawahar & Lakshmi, 2017). Compared to African peers, South Africa falls behind Egypt with a notable 30 to 60 days for products approved by the European Medicine Agency and the U.S. Food and Drug Administration (Egyptian Drug Authority, 2022). However, the Egyptian Drug Authority and South African Health Products Regulatory Authority received recognition from the World Health Organisation in 2022, affirming their well-functioning regulatory frameworks. Hopefully, South Africa will gradually improve approval time without compromising the required quality of products.

Further challenges facing the South African pharmaceutical sector in South Africa include over-reliance on imported APIs and the widespread misuse and abuse of over-the-counter medications and prescription drugs (Veitch, 2020). Drug abuse has been singled out as one of the main threats plaguing the pharmaceutical industry in South Africa and other countries (Mumbauer *et al*., 2024). Products are scheduled based on safety and medicinal risk factors, including potential abuse or drug dependence. For instance, in South Africa, the most

commonly abused over-the-counter drugs include pain relievers such as ibuprofen and aspirin, and codeine-based cough syrups, which are particularly popular among the youth for their "feel good" effects (Mumbauer *et al*., 2024). Furthermore, the sector grappled with issues related to inadequate quality control of essential hygiene products such as hand sanitizers witnessed during COVID-19, and the potential emergence of new infectious diseases, adding further complexity to the industry.

Pharmaceutical production commonly depends on patented formulas protected by intellectual property rights. This restriction limits companies' ability to produce certain medications without licensing agreements or paying royalties to multinational corporations. South Africa has been criticized for having weak patent standards, which opens the country up to frivolous and abusive patenting, where patent holders slightly modify the original to extend the patent beyond the standard of 20 years (Rayment, 2020). This makes the price of medicines to be artificially high for an extended period of time, which contributes to a lack of affordability (Appendix C). Higher prices of medicines in South Africa led to the "Fix the Patent Laws" campaign led by the Treatment Action Campaign (TAC) against the then minister of the Department of Trade and Industry (Tomlinson, 2019). While it is important to address the issue of patents, Te Naudé and Luiz (2013) caution against the emphasis on local provision of cheaper generic medicines and essential drugs, which seems to threaten the market share of patented innovative medicines. They argue that the production of medicines and the marketing of patented products are also at risk from issues related to Intellectual Property and price controls.

Despite the highlighted challenges, the South African pharmaceutical industry also has opportunities to be explored. First, Meloney and Segal (2007) observed that the sector has the potential for growth in the supply of drugs for infectious diseases in sub-Saharan Africa in partnership with other countries. Second, the increase in demand for generic medicines in South Africa also provides an opportunity for growth in the manufacturing of pharmaceuticals, although Te Naudé and Luiz (2013) raised concerns on this issue. Third, trade agreements like the bilateral trade between South Africa and India provide opportunities for skills development where India could locate more pharmaceutical companies in South Africa instead of meeting South Africa's demand through trade only (Rayment, 2020). Also, trade under the AfCFTA offers an opportunity for South Africa to expand its pharmaceutical exports beyond SADC.

While South Africa faces challenges such as high medicine prices and increasing competition from other African countries, the country's pharmaceutical sector continues to play a critical role in Southern Africa. With appropriate government regulation, investment in the latest technologies, human resources, and research and development, the sector has the potential to exploit the available opportunities to expand and increase export quantities.

2.6 Summary and Conclusion

This chapter discussed the South African pharmaceutical sector, highlighting its importance in the healthcare system and regulatory policies governing drug approval, market access, and pricing. The chapter also highlighted concerns around the protection of intellectual property rights, affordability, and accessibility to medicine, which leads to problems such as the selling of counterfeit drugs. Regarding trade, the South African pharmaceutical sector has low exports and significantly high imports driven by imports of APIs. Reliance on imported raw materials combined with the weak currency contributes to high prices of medicines. Other challenges identified include the prevalence of counterfeit products, lengthy drug approval processes, and abuse of over-the-counter medications. Despite the presence of challenges, there are still opportunities for growth and innovation, mainly through collaborations and intra-African trade enabled by the formation of AfCFTA. A balanced approach that addresses regulatory, pricing, trade, and innovation concerns will be essential to achieve sustainable growth in the South African pharmaceutical sector that is less susceptible to external shocks. The next chapter reviews the theoretical and empirical literature on international trade and absorptive capacity.

Chapter 3
Review of Theoretical and Empirical Literature

3.1 Introduction

This chapter discusses trade theories that have traditionally shaped the general understanding of international trade, which also provided the lens to examine international trade within the South African Pharmaceutical sector. These theories include the theory of comparative advantage, the Heckscher-Ohlin factor endowment theory, the Imitation Lag Hypothesis, the Product Cycle Theory, the Intra-Industry Trade theory, and the so-called 'new-new' trade theory. The discussion proceeds to explore the concept and measurement of absorptive capacity, as well as its connection to intra-industry trade. Other nuances discussed include the convergence of absorptive capacity with innovation, industrial growth, and economic growth. To contextualize the discussion, the theoretical underpinnings are complemented by a review of empirical literature that examines the interaction between trade, innovation, absorptive capacity, and economic development in similar settings. This integrated approach enables a more robust analysis of the South African pharmaceutical trade and its potential for industrial upgrading and economic transformation.

3.2 The Evolution of Traditional Theories in International Trade

The literature on international trade seeks to explain why countries benefit from trading with one another. One of the prominent classical trade theories addressing this question is the theory of comparative advantage, introduced by David Ricardo in 1821. According to this theory, for countries to benefit from international trade, each country should specialise in producing and exporting the goods with the lowest opportunity cost and importing the ones with a high opportunity cost. The essence of the theory is that trade benefits are a product of different comparative advantages between trading countries. The theory of comparative advantage is one of the oldest and most fundamental economic propositions whose prediction has been confirmed through the empirical works of various scholars. For instance, Bernhofen & Brown (2004) tested the theory of comparative advantage by analysing Japan's 19th-century trade liberalization. Their research found that Japan exported goods with low autarky prices and imported those with high autarky prices, resulting in welfare gains, a notion that strongly supported Ricardo's theory. A recent study by Pham (2023) brought a different perspective on the theory of comparative advantage. The study examined how comparative advantage evolves as economies develop. The findings suggest that countries initially diversify their industrial

value-added and employment before re-concentrating in high-value sectors, implying that comparative advantage is dynamic rather than static (Pham, 2023).

In line with the prediction of the theory of comparative advantage, Davis (1995:203) added that technical differences become significant in trade patterns when the expansion of an individual sector does not lead to a rise in marginal opportunity costs. This interpretation resonates with the pharmaceutical sector, where technical differences can be significant based on diverse research and development capabilities, manufacturing technology, regulatory environments, and product innovation. These differences imply that South Africa can develop a comparative advantage in producing pharmaceutical products in categories where firms invest in enhancing their capacity to acquire, assimilate and apply new knowledge into their production processes. Empirical studies indicate that emerging economies with strong institutional support and knowledge transfer mechanisms can benefit from such investments to stimulate industrial growth and global competitiveness (Narula, 2004). Improving absorptive capacity to incorporate global advancements in pharmaceutical technology can enable the sector to expand without significantly increasing the marginal opportunity costs by streamlining production, increasing efficiency, and thus potentially lowering the cost per additional unit produced (Lane *et al*., 2006). While the theory of comparative advantage provides a useful framework for analysing trade in the South African pharmaceutical sector it does not explain why countries have differing comparative advantages, an issue that Heckscher (1919) and Ohlin (1933) attributed to differing factor endowment.

The Heckscher-Ohlin (H-O) theory, developed by Eli Heckscher (1919) and later expanded by Bertil Ohlin (1933)**,** is a fundamental extension of Ricardo's theory of comparative advantage. The H-O model argues that differences in the relative abundance of labor and capital determine trade patterns between countries. Unlike Ricardo's labor-based model, which focuses on productivity differences, the H-O theory asserts that countries will specialize in producing goods that intensively use their most abundant factor. For example, a country rich in capital (e.g., the U.S.) is expected to export capital-intensive goods like automobiles, while a country abundant in labour (e.g., Bangladesh) should specialize in labour-intensive goods such as textiles. The H-O Model is based the following key assumptions:

1. Two-factor production (capital and labour): Goods require different combinations of these factors.
2. Identical production technology across countries.

3. Perfect factor mobility within a country but immobility across borders.
4. No transportation costs or trade barriers.

Clearly, the H-O model's simplistic assumptions do not reflect contemporary global trade dynamics, where technology, policy, and multinational strategies influence trade patterns. However, a significant contribution of the H-O model is the Factor-Price Equalization Theorem, which states that free trade leads to equalizing factor prices (wages and capital returns) across countries. In theory, as trade expands, wages in labour-abundant countries rise while capital returns in capital-abundant countries decline, reducing income disparities over time (Ohlin, 1933). However, the validity of the H-O model has been challenged. One major empirical challenge to the H-O model is the Leontief Paradox (Leontief, 1953). Leontief (1953) found that contrary to H-O predictions, the United States, a capital-abundant country exported labour-intensive goods while importing capital-intensive ones. This contradiction suggested that other factors, such as technology and human capital, play a more significant role in determining trade patterns than simple capital-labour ratios (Leontief, 1953). Further refinements, such as the Stolper-Samuelson Theorem, have explored how trade affects income distribution within countries. It predicts that trade benefits the owners of a country's abundant factor while harming those who own the scarce factor (Stolper & Samuelson, 1941). This explains why trade liberalization in labour-rich countries can lead to rising wages, whereas in capital-rich countries, capital owners gain at the expense of workers.

However, the South African pharmaceutical sector presents a unique case that does not fully conform to the predictions of the Stolper-Samuelson theorem or the H-O theory. South Africa has a relatively strong medical research and clinical sciences human capital base. However, it remains capital-constrained, leading to heavy dependence on imported APIs and high-value medicines from capital-abundant countries like India and China (Gereffi, 2019). As such, the H-O theory would predict that South Africa should focus on producing pharmaceuticals that rely on its abundant factors, such as biotech innovation, generic drug formulation, and certain niche markets like vaccines, where skilled labour and R&D capacities provide a competitive edge, which is not the case. The pharmaceutical sector is shaped by intellectual property regulations, R&D investment, and access to global supply chains, factors not explicitly considered in the traditional H-O model (Grossman & Helpman, 1991).

Furthermore, the pharmaceutical sector is highly capital-intensive, requiring large R&D investments, advanced manufacturing, and regulatory compliance. If South Africa lacks sufficient capital for large-scale pharmaceutical production, then, under Stolper-Samuelson, trade liberalization might benefit foreign capital investors and firms more than domestic labour, contradicting the assumption that the abundant factor (human capital) should gain.

In contrast, if trade exposes South Africa's pharmaceutical sector to competition from highly capitalized global firms, local research talent may not fully benefit, as capital constraints may prevent full utilization of their skills. Therefore, the H-O theory and the Stolper-Samuelson theorem provide useful but incomplete frameworks for understanding South Africa's pharmaceutical sector. This is because the H-O theory suggests that South Africa's pharmaceutical sector should thrive due to its strong human capital base, but its capital-intensive nature limits full specialization. Additionally, the Stolper-Samuelson theorem predicts benefits for skilled labor, yet capital constraints may shift gains to foreign investors. Targeted policies in R&D and investment are crucial to maximize local benefits.

Linder's hypothesis shifts the focus from factor endowments to demand-side determinants, arguing that countries with similar levels of per capita income and overlapping consumer preferences are more likely to trade with each other (Linder, 1961). Unlike the supply-side focus of the Heckscher-Ohlin model, Linder (1961) proposed that trade arises from 'overlapping demand' because countries produce goods to meet domestic demand and export any surplus. Linder argued that the countries likely to buy this surplus would have similar demand patterns to those of the exporting country. Therefore, his prediction that most trade would occur between countries with similar economic characteristics is not paradoxical but rather a natural outcome of trade driven by demand. In the pharmaceutical sector, this means that South Africa primarily trades with countries that have similar healthcare needs, disease burdens, and regulatory frameworks. For instance, South Africa imports a significant share of its pharmaceuticals from the European Union, particularly from Germany, Switzerland, and the United Kingdom, as these countries have well-developed pharmaceutical industries producing medicines that align with South Africa's demand profile (UN Comtrade, 2022). Similarly, South Africa exports pharmaceuticals to other African countries, especially within the SADC, where demand for essential medicines and generic drugs mirrors its own domestic requirements (Kaplan & Laing, 2005). This aligns with Linder's argument that countries with comparable income levels and consumer preferences are more likely to trade with each other, as South

Africa supplies pharmaceuticals to nations with similar healthcare structures and disease treatment priorities.

However, as highlighted in the H-O model discussion, the global pharmaceutical trade is not only driven by market demand but also by structural factors such as intellectual property regimes and patent protections, which can limit the capacity of developing countries to access affordable medicines. The South African pharmaceutical sector operates within a patent system that often favours multinational corporations, perpetuating dependence on imports rather than fostering local production (Muzaka, 2023). Thus, Linder's hypothesis is helpful in explaining South Africa's pharmaceutical trade in terms of demand overlap. However, South Africa's pharmaceutical trade is not solely determined by demand patterns but also by its capacity to adapt and integrate external knowledge, particularly in generic drug production, biotechnology, and advanced pharmaceutical manufacturing (Cohen & Levinthal, 1989). The effectiveness of technology transfer mechanisms, domestic R&D investment, and local firms' ability to reverse-engineer or improve upon imported pharmaceutical products significantly influence the extent to which South Africa can move from being the primary importer to a competitive exporter in regional and global markets. However, the speed at which South Africa can imitate and adapt advanced pharmaceutical technologies is not instantaneous, factors such as intellectual property protection, industrial capabilities, and domestic innovation policies also come into play (Muzaka, 2023). This suggests that there is a time lag between when an innovation is introduced in a leading economy and when it is successfully replicated or adapted by a follower economy, a phenomenon that Posner (1916) coined the Imitation Lag Hypothesis.

The Imitation Lag theory modifies the hypothesis in Heckscher-Ohlin's analysis that the trading countries possess the same technology. Instead, Posner (1961), like Ricardo, acknowledged that countries possess different technologies. However, Posner's theory went further than Ricardo's, proposing that when a new product is introduced, the inventing country will enjoy temporary benefits while firms in the importing country still learn to imitate the product. The Imitation Lag Hypothesis builds on Linder's theory by assuming that the trading countries have similar tastes and preferences, then incorporates time and demand adjustments. The time dimension (the imitation lag) considers the time it takes for the importing country to imitate the model of production introduced by the exporting country's firms. The demand lag considers the time it takes for consumers in the importing country to accept and use the new product as a close substitute for the products they are consuming (Posner,1961). However, the Imitation Lag

theory ignored the significant contribution of the transaction costs of accessing, learning, and adopting technology from leading countries to the imitators' delay to catch up (Teece, 1977). In the pharmaceutical sector, these costs manifest in the form of licensing fees, regulatory compliance burdens, and barriers to knowledge spillovers, all of which extend the time required for local firms to develop and commercialize competitive pharmaceutical products. As such, the Imitation Lag Hypothesis provides only a partial explanation of trade and industrial dynamics, paving the way for the Product Cycle Theory (PCT).

The PCT extends the Imitation Lag Hypothesis by illustrating how production and trade patterns shift as a product moves through its life cycle from innovation in high-income economies to eventual mass production in lower-cost regions as technological capabilities mature (Vernon, 1966). This transition is particularly relevant in the pharmaceutical industry, where drugs initially developed and patented in advanced economies gradually become more accessible through generic manufacturing in emerging markets like South Africa, once intellectual property protections expire and production efficiencies improve. The PCT's major contribution is that imitating new products may result in the initial exporter losing its competitive advantage to its trading partners. Some consumers from the initial exporting country may prefer the version of the imitating firms' products. Eventually, the exporting country becomes an importer of the commodity. However, the PCT is primarily based on the belief that developed countries launch new products for local consumers and later introduce the product to developing countries. This implies that innovation flows from the developed countries to the less developed.

While some scholars support the PCT (Udokporo, 2021; Osland, 1991; Mullor-Sebastian, 1983), others question its validity for a number of reasons. Kozłowski (2011) offers four points highlighting that the PCT is increasingly losing its validity. First, the emergence of the Triad, BRIC,[6] challenged the notion that innovation starts in developed economies and later spreads to developing countries because these countries have become major innovators and exporters. Second, product ideas are not necessarily born in developed countries but everywhere where the activities of companies are as multinational firms establish research and development hubs in emerging markets. Some ground-breaking products now originate in developing countries, proving that innovation is not confined to the West. Third, the PCT assumes a linear and

[6] BRIC- Brazil, Russia, India, and China, which later added South Africa, Saudi Arabia, Egypt, United Arab Emirates, Iran, and Ethiopia.

sequential process where technology moves slowly from developed to developing countries. However, globalization has significantly reduced this lag because companies today operate in interconnected markets, rapidly sharing technology, expertise, and production methods across countries. Fourth, firms now choose production and innovation sites based on cost efficiency, market demand, and resource availability, rather than just following a set life cycle. For example, China has become a global leader in high-tech manufacturing and R&D, rather than just being a late-stage producer as PCT would suggest. Moreover, the internet has made it easier for small and medium-sized companies to operate in international markets from their very establishment.

Further criticism of the Product Cycle Theory centers on the concept of reverse innovation. This concept refers to introducing an innovative product or process in a developing or emerging market and launching it in advanced economies or developed countries. Reverse innovation suggests that ideas flow from emerging to more developed economies (DePasse *et al*.,2013). This challenges the conventional assumptions of the PCT, which concentrates on innovation originating in advanced economies and spreading to developing markets (Malodia *et al*., 2020; Von Zedtwitz *et al*., 2015; Ostraszewska & Tylec, 2015; Govindarajan & Euchner, 2012; Govindarajan & Ramamurti, 2011). Reverse innovation emphasizes emerging markets' growing influence and potential in driving global innovation. Ostraszewska &Tylec (2015) argue that research on innovation implemented in poor, developing countries generates significantly lower costs than in the case of laboratories held in developed countries. It is, therefore, reasonable to expect that intra-industry trade in the South African pharmaceutical sector could promote innovation by either aligning with the traditional product cycle theory, where advanced economies lead the process or through reverse innovation, where emerging markets like South Africa play a central role in driving innovative developments.

3.3 New Trade Theory: Intra-Industry Trade

While traditional trade theories emphasize the exchange of goods based on comparative advantage, a growing share of global trade now occurs between countries with similar economies, a pattern known as Intra-Industry Trade. Intra-industry trade refers to the exchange of similar products or services within the same industry between countries, rather than trading completely different goods based on comparative advantage (Krugman & Obstfeld, 2009). Unlike traditional trade theories, which suggest that countries export what they produce efficiently and import what they lack, intra-industry trade occurs when both countries import

and export goods within the same industry category (Grubel & Lloyd, 1975). This is common in sectors such as automobiles, electronics, and pharmaceuticals, where different varieties of the same product are traded internationally. The Grubel-Lloyd (1975) index has been widely used as a standard measure of intra-industry trade. However, the Grubel-Lloyd index has been criticized severely, leading to the development of alternative models discussed in Chapter 5.

Scholars in international trade, such as Eaton and Kierzkowski (1984), Helpman (1981), (1980), Krugman (1979, 1981), and Lancaster (1976) agree that trade has evolved from inter-industry to more intra-industry trade. The shift from traditional trade patterns sparked interest in understanding the underlying factors driving intra-industry trade. As such, scholars examined intra-industry trade to determine if its underpinnings align with the existing trade theories. Differing conclusions have been reached in this regard, with some maintaining that intra-industry trade can be explained through the lenses of comparative advantage and factor endowment theories (Ddudovkiy, 2012; Brülhart, 2008; Ruffin, 1999; Davis, 1995; Helpman, 1981; and Finger, 1975). In contrast, others criticized these theories for inadequately explaining the new trade patterns (Kierzkowski, 1987; Greenaway & Milner, 1983; Krugman, 1981; Falvey, 1981; Gray, 1976). Specifically, the theories of comparative advantage and factor endowment were criticized for failing to explain significant trade volumes between countries with similar factor endowments and technology, as well as for failing to capture the role of product differentiation and economies of scale. As such, Eaton and Kierzkowski (1984), Helpman (1981), (1980), Krugman (1979, 1981), and Lancaster (1976) pioneered the groundwork in the field of intra-industry trade.

The increasing importance of intra-industry trade and the presence of large multinational corporations have reshaped economists' perspectives on the benefits of trade. Previously, the focus was on gains resulting from either differences in resource endowments (like trading wheat for iron ore) or comparative advantage across industries (as in David Ricardo's example of cloth and wine). However, today's analysis focuses on three critical sources of trade benefits. Firstly, the gains linked to intra-industry trade stem from a desire for variety. Secondly, the efficiency gains resulting from the allocation of labor and capital away from small, less productive firms, and towards larger, more productive firms. Finally, there are the gains associated with trade-induced innovation that enhance productive efficiency (Melitz & Trefler, 2012).

If most of the trade growth is intra-industry, then industries benefit from lower adjustment costs as the disruption to factor markets is likely to be minimal during trade expansion because each

industry produces differentiated varieties, which have similar factor requirements (Menon & Dixon, 1997; Greenaway *et al*., 1995; Brülhart, 1994; Hamilton & Kniest, 1991; Helpman & Krugman, 1985; Helpman, 1981). Moreover, intra-industry trade may stimulate innovation, increase investment in knowledge-based capital, facilitate joint research, and increase specialization. All these benefits would boost intra-industry trade, leading to increased productivity, industrial expansion and depth, and industrial performance. This implies that industries that engage in intra-industry trade are less prone to substantial adjustment costs like retraining workers, upgrading technology or infrastructure, relocating to a new area, or complying with new regulations. These costs may decrease profits for firms in the short run, potentially restricting new firms from entering the market. Consequently, the level of local manufacturing decreases while the appetite to source cheap imports increases. High adjustment costs perpetuate dependence on imported products and increase the industry's vulnerability to external shocks.

The long-term effect of sustained import dependence in South Africa's pharmaceutical sector is the progressive erosion of domestic manufacturing capabilities and increased vulnerability to external shocks. As local production declines due to high adjustment costs and the continued preference for cheap imports, the country risks a deepening structural dependency that may lead to de-industrialisation, reduced technological learning, and limited participation in global pharmaceutical value chains. This dependency not only weakens the sector's contribution to economic growth and employment but also increases exposure to global supply disruptions, as seen during the COVID-19 pandemic, and undermines national health security. To mitigate risks, South Africa's pharmaceutical sector should focus on building strategic capabilities to enhance its absorptive capacity. Key strategies include investing more in R&D and human capital, promoting technology transfer through partnerships, and improving regulatory frameworks to lower local production costs. Increasing participation in regional trade within SADC can also facilitate knowledge exchange. Furthermore, improved coordination among trade, industrial, and health policies is essential to reduce fragmentation and support local manufacturing, ultimately strengthening the sector's competitiveness and reducing import dependency.

The South African pharmaceutical sector would benefit from intensifying intra-industry trade, as it allows for a smoother transition during trade expansion by mitigating adjustment costs and encouraging specialization. This could stimulate local manufacturing, enhance knowledge

transfer, and foster innovation, ultimately reducing reliance on imports. By building capacity within the sector, firms can become more competitive globally while safeguarding against external shocks such as supply chain disruptions. Over time, increased intra-industry trade can drive industrial growth, improve productivity, and support the sector's contribution to domestic healthcare objectives and broader economic development.

Paul Krugman's New Trade Theory revolutionized the field of international trade economics. Krugman (1979, 1980, and 1984) is a notable scholar who used Lancaster's framework in his studies. Lancaster (1980) argued that firms have some market power under monopolistic competition and can produce various differentiated products, leading to intra-industry trade between countries. The central concepts in Lancaster's theory are ‘product space’ and ‘product characteristics.’ Product space implies that products can be arranged in a multi-dimensional product space based on various characteristics such as quality, design, and brand. Countries with similar preferences and abilities will trade products close in this space.

Product characteristics within each category imply that products can be distinguished by their characteristics, and consumers may prefer specific attributes. For example, in the pharmaceutical sector, drugs can vary by their mode of delivery, such as oral, injectable, or topical applications, their targeted effectiveness for particular diseases, or their affordability and accessibility. Patients and healthcare providers may prioritize attributes like quicker relief, fewer adverse effects, or ease of use, reflecting the diversity in product offerings. This differentiation fosters intra-industry trade by encouraging firms to develop specialized pharmaceutical products to meet the nuanced needs of various markets. These differences provide a premise for trade within the industry because it would not make sense for a country to import a good identical to what is produced domestically. Product differentiation and imperfect competition have been bases for repeatedly attesting and justifying intra-industry trade as a new approach to international trade (Fontagné *et al*., 2005). Finally, product differentiation, economies of scale, and monopolistic competition seem to be the primary determinants of intra-industry trade. The pharmaceutical industry produces various differentiated products and possesses elements of monopolistic competition; therefore, it reasons that Lancaster (1980) provides a theoretical framework underpinning this study.

3.4 New-new trade theory

After Krugman’s theory, the professed “New” New Trade Theory (NNTT) emerged. This theory focused on the “firm’s view” rather than the “sectoral view” of trade. The motivation for

NNTT rests on the observation that firms from the same industry may have different abilities to survive international competition, which implies heterogeneity of firms within the same industry (Ottaviano, 2011). Ciuriak *et al*. (2011) highlighted the following stylized facts that new-new trade literature has generally agreed on, with subsidiary implications:

1. *Participation in international markets is relatively rare among firms, and export and import intensity among firms that do participate in international markets is low:*
    - *Relatively few firms in an industry export and/or use imported inputs.*
    - *Exporters export only a small portion of their production and import inputs only account for a small share of firms' inputs.*

2. *Firms that participate in international markets are different than those that do not:*
    - *Exporters, firms that use imported inputs, and firms that engage in foreign direct investment tend to be larger, more productive, relatively more capital- and skilled labour-intensive, and pay higher wages than firms that do not participate in international markets.*
    - *Firms entering export markets grow faster in terms of employment and output than non-exporters.*

Melitz (2003) examined the intra-industry trade effects of international trade by developing a dynamic industry model with differing firms in the same industry. The dynamic industry model shows that when heterogeneous firms are exposed to trade, only the highly productive firms will be induced to enter the export market. The less productive firms will continue to produce only for the domestic market, while the least productive firms will be forced out of the market. This notion emphasizes the existence of export market entry costs. The main claim of the dynamic industry model is that the export entry costs significantly impact how trade effects are distributed across different types of firms. More exposure to trade leads to further inter-firm reallocations in favour of more productive firms. The main insight that can be drawn from Melitz's assertion is that trade is still beneficial and improves national welfare despite the existence of export market entry costs.

Melitz's dynamic industry model is particularly relevant to the South African pharmaceutical sector, where firms face significant export market entry costs due to stringent regulatory requirements, high research and development expenses, and competition from well-established global players. These costs mean that only the most competitive and productive firms are likely to succeed in exporting, while less productive firms may remain focused on domestic markets. Increased exposure to international trade could foster a shift of resources toward highly productive firms, enabling them to innovate, expand, and strengthen the sector's global

competitiveness, ultimately contributing to national welfare despite the challenges of market entry.

3.5 The concept of Absorptive capacity

The concept of absorptive capacity has been a subject of investigation in business research (Darwish *et al.*, 2020; Müller *et al*., 2020; Strøm-Andersen, 2020; Limaj & Bernroider, 2019; Gkypali *et al*., 2018; Najafi-Tavani *et al.*, 2018; Zou et al., 2018; Enkel *et al.*, 2017; Imbriani *et al.*, 2014; Qian & Acs, 2013). It refers to a country's ability to acquire, assimilate, and effectively utilize new knowledge, technologies, and innovations (Harris & Yan, 2019; Falvey *et al*., 2007). The concept was introduced by Cohen and Leventhal (1989) in their seminal work, which conceptualized absorptive capacity as the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends. They identified absorptive capacity as a key determinant of a firm's ability to learn from external sources and innovate (Cohen & Leventhal, 1989). Absorptive capacity is important in a firm's ability to innovate and achieve sustainable competitive advantage. High absorptive capacity can lead to improved efficiency, competitiveness, and growth, while low absorptive capacity can hinder the ability of an organization to adapt and grow. This means countries with higher absorptive capacity can learn from foreign technologies, ideas, and best practices more efficiently, leading to increased productivity, innovation, and competitiveness.

In cases where there is an undesirable technological gap between the firm's technology and the technology available in the market, the firm's productivity is negatively affected. Higher absorptive capacity better equips the firms to close the gap faster and improve productivity through inward investment and acquisition of new technology (Castellani & Zanfei, 2003). The speed and efficiency with which a firm can absorb new knowledge is critical to its competitiveness and long-term success. A combination of human capital, prior knowledge, culture, organizational structure, information systems, and experience is essential in ensuring that the organization can identify and acquire new knowledge and technology effectively and put it to use. Thus, absorptive capacity facilitates knowledge accumulation and subsequent utilization since utilizing knowledge acquired externally often involves transforming its content into a usable format.

Scholars have sought to reconceptualize the concept of absorptive capacity, arguing that it has been treated as a fixed and universal construct. They emphasize that absorptive capacity is dynamic, context-specific, and multifaceted (Lane & Pathak, 2006; Zahra & George, 2002).

Zahra and George (2002) propose that absorptive capacity consists of multiple dimensions rather than being a singular construct. These dimensions involve the ability to recognize and acquire valuable external knowledge, assimilate it into existing knowledge structures, transform or modify knowledge to fit organizational needs, and, finally, exploit the knowledge effectively for innovation and competitive advantage. They emphasize its dynamic nature, arguing that it is not a static capability but evolves through learning processes and organizational experiences. Reconceptualization of absorptive capacity into four dimensions seems to be welcomed by many scholars and practitioners, as subsequent literature that advances the understanding of absorptive capacity is based on these four dimensions.

Building on Zahra and George (2002), Lane and Pathak (2006) provide a critical review of the concept of absorptive capacity and its application in organizational research, calling for a rejuvenation of the construct, suggesting that it should be viewed as a process that is influenced by a variety of contextual factors, such as organizational culture, structure, and strategy. They argue that it is important to consider how these factors can impact an organization's ability to acquire, assimilate, transform, and exploit new knowledge. Lane and Pathak (2006), and Zahra and George (2002) contributed to a better understanding of absorptive capacity. However, Zahra and George (2002) focused on expanding and refining the concept, while Lane and Pathak (2006) addressed critical issues regarding how absorptive capacity is approached and utilized in research and practice.

Furthermore, Camisón and Forés (2010) provided new insights into how absorptive capacity should be understood and operationalized, focusing on conceptualization and measurement. In terms of conceptualization, the authors dissected the four dimensions of absorptive capacity into two classifications, Potential Absorptive Capacity (PACAP) and Realised Absorptive Capacity (RACAP). The PACAP comprises acquisition and assimilation capacity, while RACAP comprises transformation and application capacity. They argue that externally acquired knowledge undergoes multiple iterative processes before the firm can successfully apply this knowledge to create value.

To illustrate the point made by Camisón and Forés (2010), consider a pharmaceutical company based in South Africa that specializes in developing novel therapies for rare diseases. The company actively engages in international trade by importing raw materials, active pharmaceutical ingredients (APIs), and advanced drug delivery technologies from suppliers in

countries like Switzerland, India, and Germany. The processes involved in applying this externally acquired knowledge to create value would go as follows:

> *Through international trade, a pharmaceutical company identifies innovative APIs, formulation techniques, and drug delivery systems from foreign suppliers, such as specialized compounds for targeted drug delivery from Swiss suppliers and advanced manufacturing equipment from German suppliers. Acquiring these innovations through trade agreements and collaborations, the company's research teams engage in learning activities to understand their properties and potential therapeutic applications. They seamlessly integrate these innovations into drug development processes, conduct rigorous preclinical and clinical testing, scale up manufacturing with high-quality materials and adherence to regulations, and finally launch new medications. These innovations from international trade contribute to effective treatments, improved outcomes for rare diseases, revenue generation, and bolster the company's position in the pharmaceutical industry.*

The concept of absorptive capacity is a multifaceted and dynamic process that plays a pivotal role in organizational learning, innovation, and competitiveness. By recognizing the importance of external knowledge acquisition, assimilation, transformation, and exploitation, organizations can enhance their ability to adapt to changing environments, leverage new opportunities, and create sustainable value. Researchers and practitioners must adopt a holistic view of absorptive capacity, considering its various dimensions, contextual influences, and iterative learning processes. The absorptive capacity concept relates to the South African pharmaceutical sector in the context of its engagement in international trade and the need to acquire external knowledge and technology. This concept is crucial for understanding how pharmaceutical companies in South Africa can maximize international collaborations and trade agreements to enhance their innovation, competitiveness, and value creation.

Embracing a nuanced understanding of absorptive capacity enriches theoretical frameworks and guides practical strategies for organizations to effectively manage knowledge, foster collaboration, and achieve strategic goals in today’s complex and dynamic business environment. Literature on the conceptual framework of absorptive capacity suggests that consensus regarding the dimensions of absorptive capacity has been reached. However, there is still a struggle regarding its measurement, as many scholars have not managed to capture all

its four dimensions in their studies. As such, the following section discusses various attempts at measuring absorptive capacity.

3.5.1 Measurement of absorptive capacity

Extensive research has been devoted to the concept of absorptive capacity, with scholars exploring its impact on different aspects of the economy. This research has identified three main strands: the first examines the relationship between absorptive capacity and innovation, industrial growth, and economic growth; the second focuses on absorptive capacity in relation to firm size, a country's level of development, and the technology gap between the firm and the market; and the third explores the factors that contribute to the development of absorptive capacity, including prior knowledge, education, investment, institutional quality, and human capital. Some scholars have also investigated how organizations can foster the development of absorptive capacity through internal and external routines that encourage knowledge sharing, learning, and innovation. However, a consensus has yet to be reached on a single measure that captures all four dimensions of absorptive capacity proposed by Zahra and George (2002) - acquire, assimilate, transform, and exploit. This is partly due to the fact that the drivers of absorptive capacity vary across industries. As such, researchers have used various variables as proxies for absorptive capacity. The most used variables are summarized in Table 5.

Table 5: Empirical studies using various proxies to measure absorptive capacity

Author	Research topic	Dimension/proxy
Flatten, Engelen, Zahra, and Brettel (2011)	A Measure of Absorptive Capacity: Scale Development and Validation	Acquisition, Assimilation, transformation, and Exploitation
Camisón and Forés (2010)	Knowledge absorptive capacity: New insights for its conceptualization and measurement	**Potential absorptive capacity (CAPOT)** **Acquisition capacity:** Knowledge of the competition, Openness towards the environment, R&D cooperation, and Internal development of technological competencies. **Assimilation capacity:** Assimilation of technology, Human resources Industrial benchmarking, Involvement in spreading knowledge, Attendance at training courses and professional events, Knowledge management. **Realized absorptive capacity.** **Transformation capacity:** Transmission of IT-based knowledge, Renewal capability, Adaptation capacity Exchange of scientific and technological information, Integration of R&D **Application capacity:** New knowledge exploitation, Application of experience Development of patents, Technological proactiveness
Kim (1995)	Absorptive Capacity and Industrial Growth: A Conceptual Framework and Korea's Experience	**Prior knowledge:** Formal education, General education Technical education, Vocational training **Intensity of efforts:** Research and development, production
Zahra & George (2002)	Absorptive capacity: a review, Reconceptualization, and extension.	**Acquisition:** Prior Investments, Prior knowledge, Intensity, Speed, and Direction **Assimilation:** Understanding **Transformation:** Internalization and Conversion **Exploitation:** Use and Implementation
Hurtado & González-Campo (2015).	Measurement of knowledge absorptive capacity: an estimated indicator for the manufacturing sector in Colombia.	**Acquisition:** R&D investment, Technology Transfer Investment, Investment in Machinery and Equipment. **Assimilation:** Supplier cooperation, Institution cooperation, Client cooperation. **Transformation**: Staff involved in Technology and innovation activities, Support in technical assistance and consulting. **Exploitation:** Innovation in production methods, improvement in the quality of products and/or services, Broadening the range of products and/or services.
Harris and Yan (2019)	The Measurement Of Absorptive Capacity from an Economics Perspective: Definition, Measurement and Importance	**Quantitative methods:** Patents, R&D Expenditure, and Human Capital **Qualitative methods:** Expert Surveys and Case Studies
Xia and Roper (2016)	Unpacking Open Innovation: Absorptive Capacity, Exploratory and Exploitative Openness, and the Growth of Entrepreneurial Biopharmaceutical Firms	**Potential ACAP Indicators:** R&D Intensity, Employee Skills, Continuous R&D **Realised ACAP Indicators:** No. of Patents

Source: Flatten et al. (2011) and Author's own construction.

The information presented in Table 5 offers a comprehensive overview of the research done on absorptive capacity. There is a significant difference in the methods scholars have used to

measure absorptive capacity. Therefore, it is crucial to use a proxy encompassing all aspects of absorptive capacity relevant to specific industries. Without an accurate measurement, it becomes challenging to identify the factors that impact absorptive capacity, which can impede efforts to improve it effectively. This limitation raises the question of how countries can enhance their absorptive capacity to benefit fully from global trade. To address this issue, we need a robust measurement framework covering the essential components of absorptive capacity: acquisition, assimilation, transformation, and exploitation. This framework should be precise and dependable, facilitating comparative analysis and providing practical insights to policymakers and practitioners aiming to strengthen absorptive capacity and seize opportunities in the global marketplace.

3.5.2 Exploring Convergence of Absorptive Capacity, Innovation, Industrial and Economic Growth.

There is a vast literature on the relationship between absorptive capacity, innovation, and economic and industrial growth. This literature has explored the topic from various perspectives. Absorptive capacity is also commended for fostering innovation and productivity, leading to growth in the industry and, ultimately, the economy at large. This section examines mechanisms through which absorptive capacity influences economic dynamics, the policy implications for fostering a conducive environment for knowledge absorption, and long-term economic resilience and prosperity. The following subsections examine the relationship between absorptive capacity and its effects on innovation, Foreign Direct Investment, and industrial and economic growth.

3.5.2 (a) Absorptive Capacity and Innovation

Literature on absorptive capacity highlights the crucial role that absorptive capacity plays in driving innovation within economies. Innovation refers to the process of generating and implementing new ideas, products, services, processes, or business models that create value. Enkel *et al*. (2017) further dissect innovation into exploratory and exploitative innovation. Exploratory innovation refers to developing new and unconventional products, processes, or business models, while exploitative innovation refers to improving existing products. While there is consensus about the deep connection between absorptive capacity and innovation, scholars hold differing views in relation to the nature of the relationship. Ahmed *et al* (2024) argue that only knowledge assimilation and transformation dimensions of absorptive capacity positively influence innovative performance, while knowledge acquisition may have an adverse effect. On the contrary, Huma *et al*. (2024) assert that both potential absorptive capacity

(PACAP) and realized absorptive capacity (RACAP) dimensions significantly contribute to innovation strategies. Absorptive capacity is crucial for enabling both facets of innovation within organizations. It fuels innovation and technological advancement, enhances productivity, fosters industrial competitiveness, and drives long-term economic growth. As such, some studies look into the impact of absorptive capacity on industry and economic growth (Kinoshita & Lu, 2006; Kim, 1995; Arrow *et al.,* 1995; Grossman & Helpman, 1991).

3.5.2 (b) Absorptive Capacity and FDI

The pioneering journey into the relationship between international trade, knowledge spillovers, and economic growth is found in the work of Grossman and Helpman (1991). They studied the relationship between trade, knowledge spillovers, and growth by developing a theoretical model to explain how trade and foreign investment can promote knowledge spillovers and economic growth. Their main argument was that trade and foreign investment can lead to the diffusion of knowledge across countries, which can enhance the growth of the recipient country. This study highlights the importance of quality human capital as key to understanding and efficiently utilizing the new knowledge to maximize the benefits of trade and investment for knowledge spillovers.

The relationship between knowledge spillovers and FDI is synergistic, with FDI serving as a key channel for transferring advanced technologies, managerial expertise, and innovative practices to host economies. These spillovers occur through labour mobility, supply chain interactions, and competitive pressures, fostering productivity gains among domestic firms. However, the extent of these benefits depends on the host country's absorptive capacity, which is shaped by factors like human capital, R&D investment, and institutional quality. At the same time, knowledge spillovers can attract FDI, as multinational corporations seek collaborative opportunities in innovation-driven sectors. To maximize these benefits, policymakers should enhance education, strengthen local research ecosystems, improve governance, and encourage linkages between MNCs and domestic firms to create a conducive environment for mutual knowledge exchange and economic growth.

Subsequent studies exploring the nexus between absorptive capacity, Foreign Direct Investment (FDI), and economic growth emerged. Although these studies view these relationships from different angles, they agree on four key issues. First, FDI is one of the most important channels through which technology embodied in human capital can be transferred. Second, high levels

of absorptive capacity positively impact the benefits derived from FDI because firms with higher absorptive capacity tend to gain more benefits from FDI. Third, absorptive capacity fosters innovation and enables effective knowledge utilization and transfer, positively contributing to economic growth and global competitiveness. Lastly, countries with higher levels of absorptive capacity experience faster economic growth, while countries with lower levels of absorptive capacity experience slower economic growth (Tang & Zhang, 2016; Zou *et al*., 2016; Castellacci & Natera, 2016; Kinoshita & Lu, 2006; Kinoshita, 2000). These studies highlight the significance of absorptive capacity and FDI in driving economic progress and enhancing competitiveness on the global stage.

3.5.2 (c) Absorptive Capacity and Economic Growth

There appears to be a consensus that countries significantly differ in their absorptive capacity. While some scholars have explored how these differences impact various economic aspects, others have focused on the underlying causes of the differences. Castellacci and Natera (2016) argue that countries vary not only in the nature of their innovations but also in their level of economic development and the strength of their institutional environments. These disparities arise from differing absorptive capacities, which are crucial in shaping a nation's approach to innovation and its overall economic trajectory.

The importance of absorptive capacity in determining the path of industrial growth is widely acknowledged. Kim (1995) identifies it as a key factor influencing how effectively an industry can adapt to external changes, drive innovations, and ultimately achieve sustainable growth. However, for firms to successfully absorb and utilize new technologies and external knowledge, there is a need for policy interventions that support the development of absorptive capacity, thereby promoting industrial growth and competitiveness.

In examining the reasons behind varying absorptive capacities, Darwish *et al*. (2020) highlight the critical role of leadership in fostering organizational learning related to absorptive capacity and innovation. They contend that leaders are essential in cultivating a supportive organizational culture, encouraging learning and collaboration, and providing the necessary resources and support for innovation activities. Additionally, other studies have identified factors such as relative backwardness, technology gaps, firm size, and regional characteristics as key determinants of absorptive capacity (Imbriani *et al*., 2014; Falvey *et al*., 2007; Castellani & Zanfei, 2003).

Empirical evidence regarding relative backwardness revealed that the more backward a country, the higher its growth. However, the largest spillovers accrue to countries that are not too backward but still sufficiently far from the frontier that significant foreign knowledge remains unexploited (Falvey *et al*., 2007). This notion highlights the importance of considering a country's level of development relative to other countries and how this can impact its ability to absorb new knowledge. With regard to the technology gap, Castellani and Zanfei (2003) show that large gaps between domestic and foreign technology tend to result in positive outcomes for foreign direct investment (FDI). However, local firms' absorptive capacity, as measured by their average productivity, does not appear to impact productivity spillovers from FDI. These findings support the 'catching up' hypothesis, which suggests that larger technological gaps lead to greater growth opportunities from foreign investments, and contradict the 'technological accumulation' hypothesis, which emphasizes the importance of domestic absorptive capacity and coherence between foreign and domestic technology for beneficial effects of inward investments. Considering the role played by the firm size and regional characteristics in shaping the firms' absorptive capacity, evidence shows a positive relationship between absorptive capacity and larger firms having a greater ability to absorb new knowledge and technologies. Furthermore, firms allocated in regions with a strong tradition of innovation and entrepreneurship have a greater ability to absorb new knowledge.

Zou *et al*. (2016), on the other hand, went further and looked at the product's life cycle to observe the stage at which the impact of absorptive capacity is the greatest. They found that the development of absorptive capacity positively impacts technological innovation and can lead to improved product performance in the market. This impact is greatest at the early stages of the product life cycle and decreases as the product matures. Their findings highlight the importance of developing absorptive capacity to capitalize on market opportunities and achieve the sustained competitive advantage necessary for industry growth.

3.8 Summary and Conclusion

This chapter interrogated various international trade theories that frame the analysis of trade dynamics within the South African pharmaceutical sector. Traditional theories such as comparative advantage and the Heckscher-Ohlin model provided a basic understanding of why countries benefit from trade. However, it was through integrating more dynamic frameworks such as the Imitation Lag theory, the Product Cycle theory, and intra-industry trade models that

a more nuanced understanding of the pharmaceutical sector's challenges and opportunities emerged. These theories highlighted the role of innovation timing, product evolution, and firm-level competitiveness in shaping trade patterns.

Furthermore, the discussion of absorptive capacity provided a lens through which to examine South Africa's ability to integrate, adapt, and exploit external knowledge and technology in pharmaceutical production. This discussion carefully established the link between absorptive capacity and some trade theories. For instance, in discussing the Imitation Lag and Product Cycle theories, it was illustrated that absorptive capacity can influence the speed and success of technology adoption and local production. By connecting theoretical perspectives to empirical realities, the chapter demonstrated that enhancing absorptive capacity is central to improving South Africa's position in the global pharmaceutical value chain and enabling sustainable export growth. Moreover, the empirical literature on absorptive capacity helped to identify the variables that determine absorptive capacity in the pharmaceutical sector. Furthermore, empirical literature also showed the interconnected nature of economic, social, and governance in shaping an economy or industry trajectory. As such, the following chapter analyses the trends of the variables identified as determinants of absorptive capacity in the South African pharmaceutical sector.

CHAPTER 4

Examining Trends in Key Determinants of Absorptive Capacity in the South African Pharmaceutical Sector.

4.1 Introduction

The firm's ability to absorb external knowledge and remain competitive in the market is influenced by many factors. These factors involve a combination of country-level and industry-specific characteristics because industries exist within certain economic, social, and political environments. Therefore, this chapter closely examines the trends of some variables likely to impact absorptive capacity in the South African pharmaceutical sector. It should be noted that the measurement of absorptive capacity cannot follow a blanket approach as each industry possesses specific attributes that contribute to its ability to absorb, adapt, and exploit external knowledge. Against this background, and based on the reviewed literature, the variables that will be examined in relation to their influence on the absorptive capacity in the South African pharmaceutical sector are as follows: Marginal Intra-Industry Trade (MIIT) and Unmatched Changes in Trade (UMCIT), pharmaceutical export growth, patent applications, investments in Research and Development (R&D), Foreign Direct Investment (FDI), Capital-Labour ratio, Trade Barriers, Human Development Index (HDI), Gross National Income (GNI), and Quality of Institutions. The detailed analysis of these variables provides a better understanding of the factors driving South Africa's pharmaceutical ability to acquire and adapt external knowledge through intra-industry trade.

4.2 MIIT and UMCIT in the South African Pharmaceutical Sector 2002 - 2021

International trade is an integral part of the South African pharmaceutical sector, as many companies either import Active Pharmaceutical Ingredients as production inputs or import final products to sell. As shown in Chapter 2, Table 4, this sector also exports products to some countries in Southern Africa. The emergence of COVID-19 amplified the importance of international trade in pharmaceuticals, as all African countries initially depended on foreign Western countries for the COVID-19 vaccine. Intra-industry trade (IIT) has become more prevalent in today's trade, facilitating the exchange of knowledge, skills, and best practices between countries or firms and promoting growth (Gkypali *et al*., 2018). IIT exposes firms to diverse knowledge sources to learn and enhance absorptive capacity and improve innovation performance, particularly in small and medium-sized enterprises (SMEs) (Siregar *et al*., 2024).

This learning process is essential for effectively absorbing and adapting new technologies and processes, strengthening a country's absorptive capacity over time (Aliasghar, 2019).

Furthermore, intra-industry trade impacts industry growth by increasing specialization within industries. When a country focuses on producing specific goods or services within an industry, economies of scale can be achieved. Economies of scale lead to a lower unit cost of production, making industries more efficient and competitive, driving industry growth (Menon & Dixon, 1997; Greenaway *et al*., 1995; Brülhart, 1994; Hamilton & Kniest, 1991; Helpman & Krugman, 1985; Helpman, 1981). Increased competition in the market encourages firms to invest in research and development (R&D), innovation, and skills development to maintain their competitive edge. This competitive pressure drives efficiency and improves effectiveness, ultimately enhancing a country's absorptive capacity. As such, one can imagine that absorptive capacity and intra-industry trade are highly correlated, although the causal relationship may not be clear at this point. The level of intra-industry trade in the South African pharmaceutical sector is depicted in Figure 4 below.

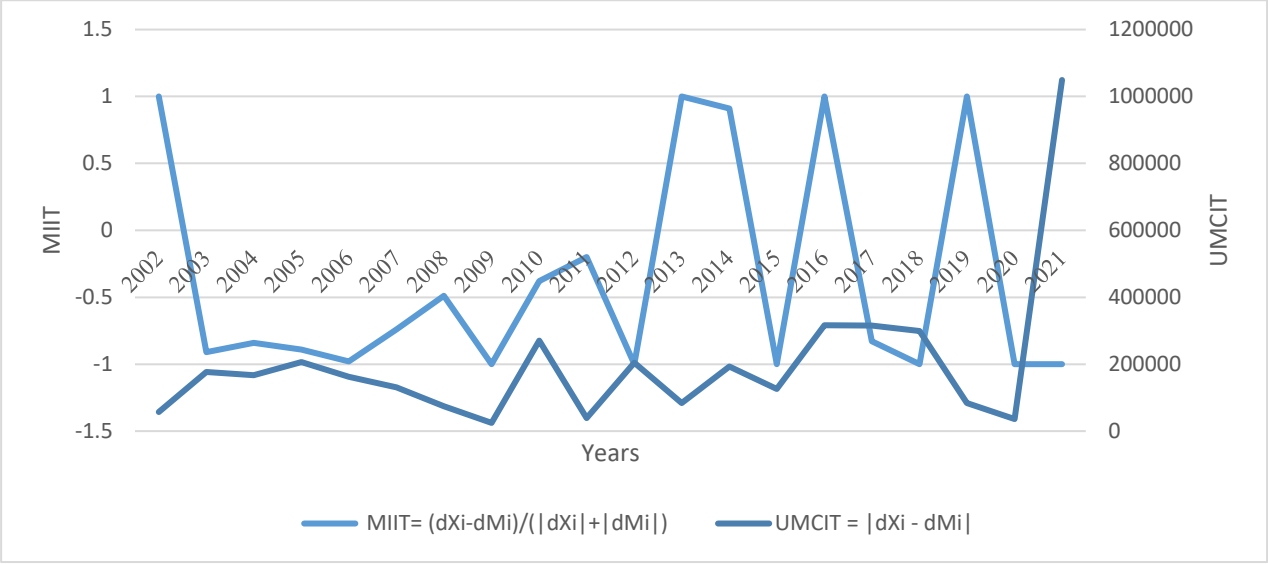

Figure 4. The trend of MIIT and UMCIT in the South African pharmaceutical sector.
Source: Author's own construction.
*Note: a) Critical values of MIIT are +/- 0.65.
b) MIIT from -1 to -0.65 means there has been specialization out of the industry
c) MIIT from - 0.65 to 0.65 means significant intra-industry changes have taken place
d) MIIT from 0.65 to 1 means there has been specialisation in the industry.

Figure 4 illustrates that new trade is predominantly inter-industry with few years of specialization within the pharmaceutical industry. This is indicated by positive MIIT or lower UMCIT values. Positive MIIT values suggest that pharmaceutical exports increased more than imports in 2002, 2013, 2014, 2016, and 2019. It would benefit the industry to consistently

increase exports more than imports to benefit from economies of scale and skill enhancement. Additionally, it can lead to increased export opportunities and partnerships. A more detailed interpretation of MIIT and UMCIT is provided in section 5.4.1 in Chapter 5, as the measurement of intra-industry trade forms part of the objectives of this study. The ongoing trend of low intra-industry raises questions about the capacity of the country to assimilate the knowledge and technological advancements embodied in pharmaceutical imports, upon which it has relied for more than two decades. Therefore, the relationship between intra-industry trade and the country's absorptive capacity should be investigated in relation to the growth of the South African pharmaceutical sector.

4.3 Exported growth for pharmaceutical products in South Africa

The growth of exports represents the percentage of growth in pharmaceutical exports. The growth of exports in any sector, including pharmaceuticals, is an important economic indicator because exports generate foreign currency and demonstrate the ability to produce globally competitive products (Hausmann *et al.*, 2007). It may also indicate the sector's resilience in withstanding obstacles that can constrain export growth. For instance, competition from international rivals offering comparable goods at lower costs or with superior quality may negatively affect South Africa's exports. The growth of exports is not just about overcoming competition but an outcome of technological innovations, skilled labor, and quality standards that meet or exceed international benchmarks. These are all factors that enhance the attractiveness of South African pharmaceutical products on the global market and contribute to the overall economic health of the country (Krugman, 1991).

Moreover, export growth exposes domestic firms to international markets, driving technology transfer and the adoption of best practices, thereby enhancing absorptive capacity. This process, known as "learning by exporting," improves skills and productivity, fostering further innovation (Salomon & Shaver, 2005). The continuous interaction with international buyers and competitors provides critical feedback and insights that drive iterative improvements and innovations in product design, quality, and operational processes (Clerides *et al*., 1998). Thus, a virtuous cycle is created where improved absorptive capacity supports higher-value exports, generating resources for further development and sustaining long-term economic growth. However, in the case of South Africa, as shown in Figure 5 below, export growth in the pharmaceutical sector is low.

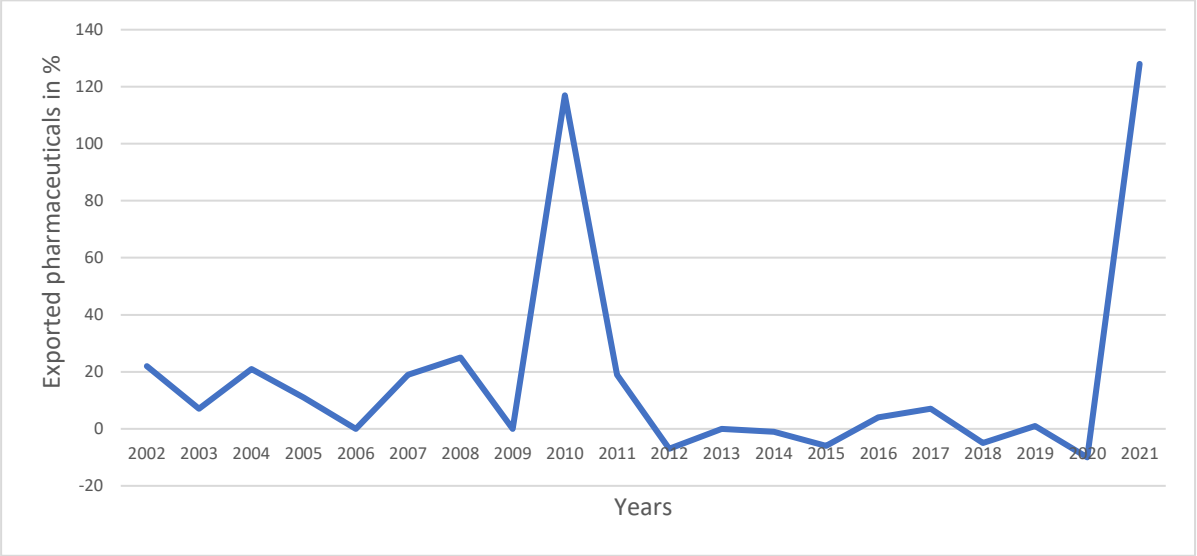

Figure 5: Exported growth in value for pharmaceutical products in South Africa
Source: Trademap (2024)

Figure 5 above shows that growth in South African pharmaceutical exports is generally low and decreasing, except in 2010 and 2021. The sharp increase observed in 2010 could be attributed to significant technological improvements driven by the integration of automation into production as manufacturers embraced the Fourth Industrial Revolution (4IR) in manufacturing (PC4IR, 2020). As highlighted in Chapter 2, another factor that could have contributed to the growth in pharmaceutical exports in 2010 was the FIFA World Cup 2010 hosted by South Africa (Niyimbanira & Surujlal, 2011). The 2021 spike, on the other hand, may have been the COVID-19 aftermath, as African countries were in need of the COVID-19 vaccine. For instance, in March 2021, the South African government sold its stock of AstraZeneca vacccines to the African Union (AU) for distribution among member states (Reuters, 2021). This study will use export growth as a variable to measure growth in the South African pharmaceutical sector.

4.4 Resident and non-resident patent applications

A patent is a legal right granted by a government to an inventor or their assignee, granting them exclusive rights to their invention for a specified period. This exclusivity enables the patent holder to prohibit others from making, using, selling, or distributing the patented invention without their permission. For a company to successfully obtain a patent, it must demonstrate a level of innovation that signifies a shift in its fundamental knowledge structure (George *et al*., 2001). This is usually achieved by effectively using knowledge generated in research and development, where systematic routines consistently produce new insights (Spender, 1996).

The quantity of patents filed determines a company's ability to effectively harness external knowledge and incorporate it into its daily operations (Zahra & George, 2002).

Essentially, a patent serves as a form of intellectual property protection that rewards inventors for their innovative creations and encourages further innovation by providing a period of exclusivity. On the contrary, some scholars argue that there is no theory or evidence linking patents to increased innovation. While acknowledging that patents can have a partial equilibrium effect of improving incentives to invent, the general equilibrium effect on innovation can be negative (Boldrin & Levine, 2013). Notwithstanding the opposing views, this study believes that it is important to create an environment that allows innovators to assimilate acquired knowledge and effectively integrate it with existing knowledge and capabilities to develop patentable inventions. This implies that absorptive capacity is crucial in transforming knowledge into tangible innovations. Therefore, similar to Xia and Roper (2016), this study includes the number of patent applications as one of the key variables in measuring absorptive capacity. Figure 6 below shows the patent applications in South Africa submitted by residents and non-residents.

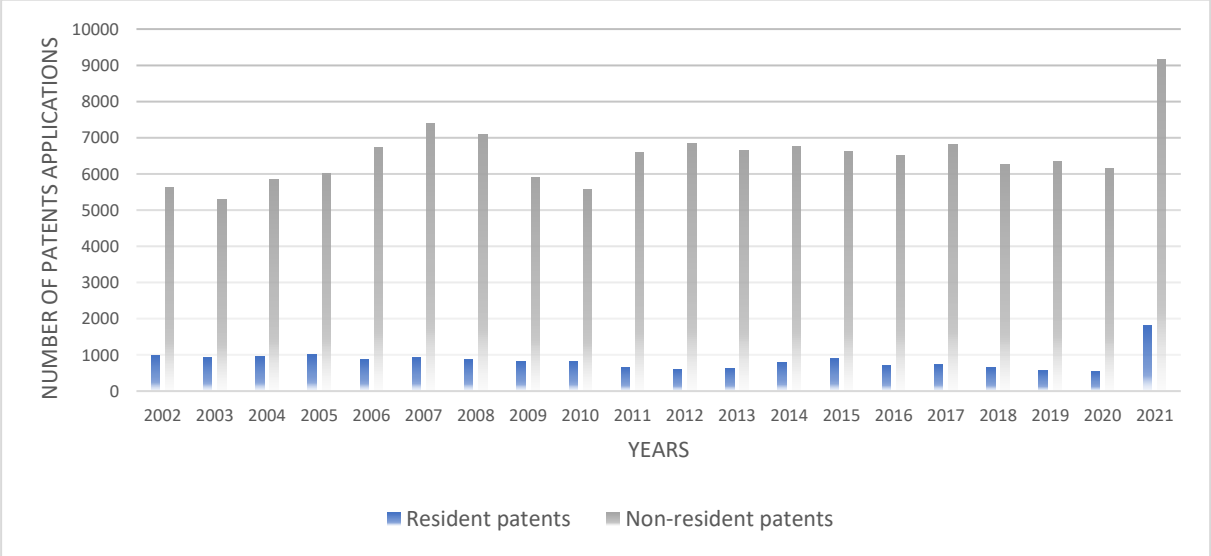

Figure 6: Patent applications in South Africa Source: WDI (2021)

Figure 6 shows a significant difference between the number of applications submitted by South African residents against non-South African residents, with non-residents submitting an average of seven times more. This implies that multinational pharmaceutical companies secure extensive patent rights, blocking local generic production, as observed in several developing countries with similar dynamics (Ncube & Rutenberg, 2021; Wen & Matsaneng, 2014). While generics themselves are not patented unless involving novel formulations or delivery methods,

local manufacturers often face significant barriers in navigating the fragmented and non-transparent patent database, which can delay or deter generic entry (Velásquez, 2015). The low number of patent applications by South African residents is concerning, as it has implications for absorptive capacity, which is a key factor in driving a company's ability to innovate and protect its innovations through patents. Organizations with strong absorptive capacity generally tend to have a higher volume of patent applications, which is essential for driving innovation in a competitive market (Balle *et al*., 2020).

4.5 Research and Development

There is a huge body of literature[7] highlighting the importance of R&D in absorptive capacity, innovation, and utilising external knowledge for competitive advantage. Many of these studies used R&D as a key variable in measuring absorptive capacity because it is viewed as a primary source of innovation by creating new knowledge, technologies, and products. Therefore, investing in R&D complements absorptive capacity by allowing firms to integrate external knowledge into their innovation processes. This, in turn, enables organisations to develop new products, enhance existing technologies, and remain competitive in rapidly evolving markets. Ultimately, R&D generates internal knowledge, and absorptive capacity facilitates the integration of external knowledge, resulting in a powerful combination that drives continuous innovation and organisational growth. As such, Figures 7 (a) and (b) below present South African expenditure in R&D expressed in million rands, as a percentage of GDP and number of researchers in R&D.

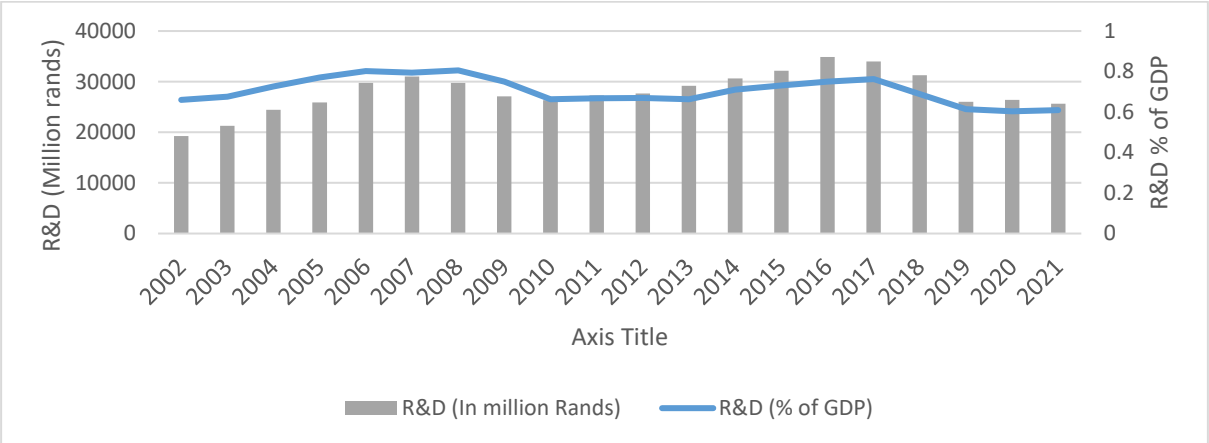

Figure 7 (a): Expenditure in Research and Development Source: WDI (2021)

[7] Harris and Yan, 2019; Xia and Roper, 2016; Zou *et al*., 2016; Hurtado & González-Campo, 2015; Camisón & Forés, 2010; Belderbos *et al*., 2004; Flor & Oltra, 2004; Griffith *et al*., 2003; Meeus *et al*.,2001; Tsai, 2001; Stock, 2001; Liu & White, 1997, Veugelers, 1997, Mowery *et al*., 1996 and Kim, 1991.

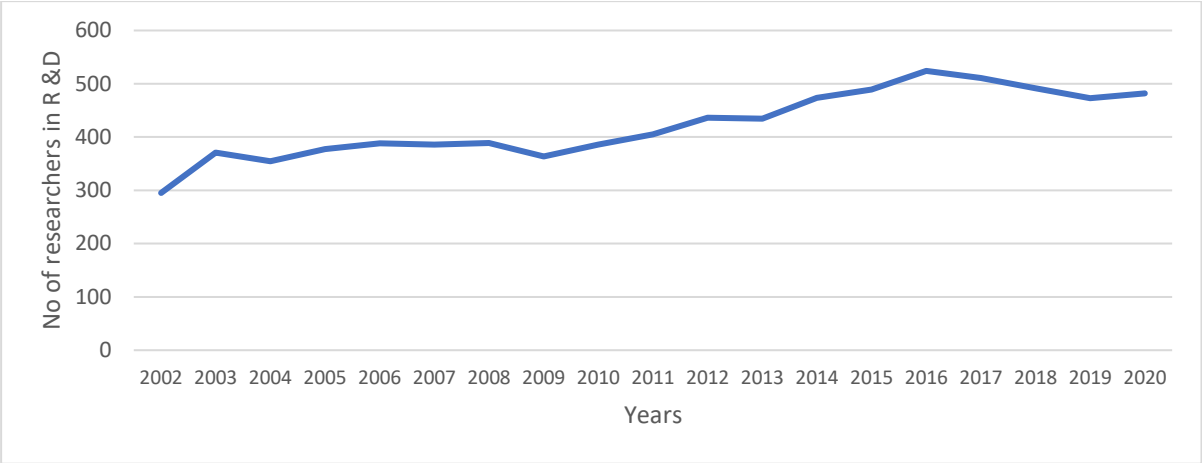

Figure 7 (b): Number of researchers in Research and Development Source: WDI (2021)

Figures 7(a) and 7(b) show that the number of researchers in research and development and R&D expenditure steadily increased from 2002 to 2007, and dropped from 2008 to 2011. The Global Financial Crisis is likely to have contributed to the observed decrease. However, there has been a gradual increase from 2012, reaching its peak in 2016 and slightly decreasing in 2019, which could be associated with the global health crisis caused by COVID-19. The study will examine how R&D expenditure in South Africa contributes to absorptive capacity in the pharmaceutical sector.

4.6 Foreign Direct Investment

Foreign Direct Investment (FDI) is a critical driver of economic growth, especially for developing countries. FDI offers many advantages and positive outcomes, including access to cutting-edge technology and spillover effects for firms and economies (Ajayi, 2006). The FDI is a form of international investment demonstrating the foreign investor's desire to establish a lasting interest in a company based in another country. FDI aims to acquire a minimum of ten percent ownership stake in the resident enterprise, resulting in significant control over its management (UNCTAD, 2000:28). This creates a long-term relationship between the direct investor and the resident enterprise, ultimately leading to mutual benefits.

Furthermore, FDI has been linked to absorptive capacity as a key channel for transferring technology embedded in human capital. Literature also points out that high levels of absorptive capacity enhance the benefits of FDI, as firms with greater absorptive capacity are more likely to reap significant advantages from it (Tang & Zhang, 2016; Zou *et al*., 2016; Castellacci & Natera, 2016; Kinoshita & Lu, 2006; and Kinoshita, 2000). Figure 8 below shows that FDI

inflow as a percentage of GDP in South Africa is very low (mostly below 2%) for most of the studied period.

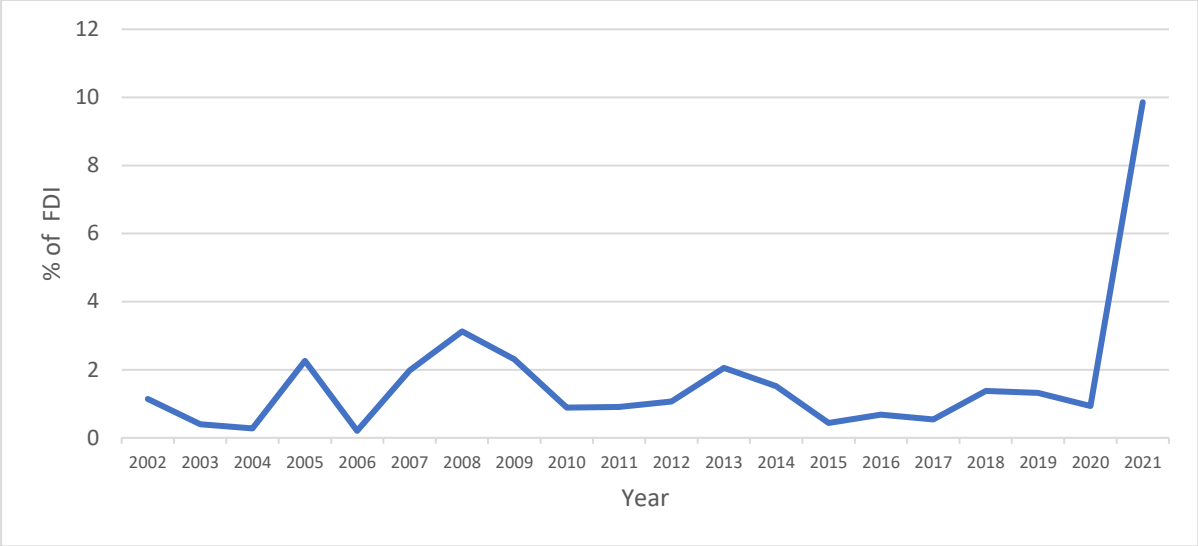

Figure 8: Inflow of Foreign Direct Investment Source: WDI (2021)

However, notable peaks occurred in certain years, like 2005, 2008, and 2013, and the highest recorded in 2021. While Figure 8 reflects the general inflow of FDI in South Africa, and not only in the pharmaceutical sectors, major events in the health sector are likely to have impacted the FDI inflow. For instance, the years 2000 to 2005 were the first decade of implementing the large-scale antiretroviral therapy (ART) programs in South Africa and Africa at large, making significant progress in providing life-saving treatment for HIV/AIDS patients (Joint Health and Treasury Task Team, 2003). This likely induced the peak in 2005, followed by a sharp decline in 2006 as the implementation program was completed. Similarly, a significant decline was observed in 2009, which was mainly driven by the Global Financial Crisis.

The major peaks in the FDI (2005, 2008, 2013, and 2021) overlap with the results obtained in Chapter 5, Section 5.4.2, where significant technological advancements in 2003, 2005, 2010, 2012, 2013, 2016, and 2021 were found. The overlap suggests a possible interplay between FDI inflows and technological advancements in the South African pharmaceutical sector during those years. This implies that the infusion of foreign capital promotes knowledge transfer, encourages innovation adoption, and enhances capacity building. Conversely, technological advancements might also create a more attractive environment for foreign investors by signaling strong future returns, thus leading to increased FDI. While these overlaps could be coincidental or part of broader economic and policy trends, they suggest a mutually reinforcing cycle where FDI and technological innovation feed into each other. As such, this study investigates how FDI affects absorptive capacity in the South African pharmaceutical sector.

4.7 Capital/ Labour ratio

The capital/labour (K/L) ratio refers to the proportion of labour input, measured by hours worked or the number of workers, to capital input, such as infrastructure, machinery, and equipment, in the production process. It is calculated by dividing the total value of all the capital by the total number of workers (or the total labor input). This ratio is normally used to assess labour utilization efficiency and is one of the factors that can boost labour productivity (Perkins *et al*., 2013). There is a strong relationship between capital/ labour ratio and absorptive capacity.

In regions with high absorptive capacity, firms can effectively utilize the capital to innovate and improve production processes, thus maximizing productivity gains from capital investments (Jung & López-Bazo, 2017). Through education and training, human capital significantly improves absorptive capacity, further amplifying the positive effects of capital investments on productivity (Elish & Elshamy, 2017). Conversely, without adequate absorptive capacity, even high capital/labour ratios may not yield significant productivity improvements, as firms may struggle to integrate new knowledge effectively (Zornoza *et al*., 2015).

Strong absorptive capacity can affect the capital/labour ratio by enabling organisations and economies to optimize their inputs more effectively. By incorporating new knowledge and innovations, productivity improvements may occur, potentially altering the balance between labour and capital inputs. As such, studies by Hurtado and González-Campo (2015), Xia and Roper (2016), and Mukherjee *et al*. (2000) have used the level of labour skills and level of technology used by labour as a variable to measure absorptive capacity.

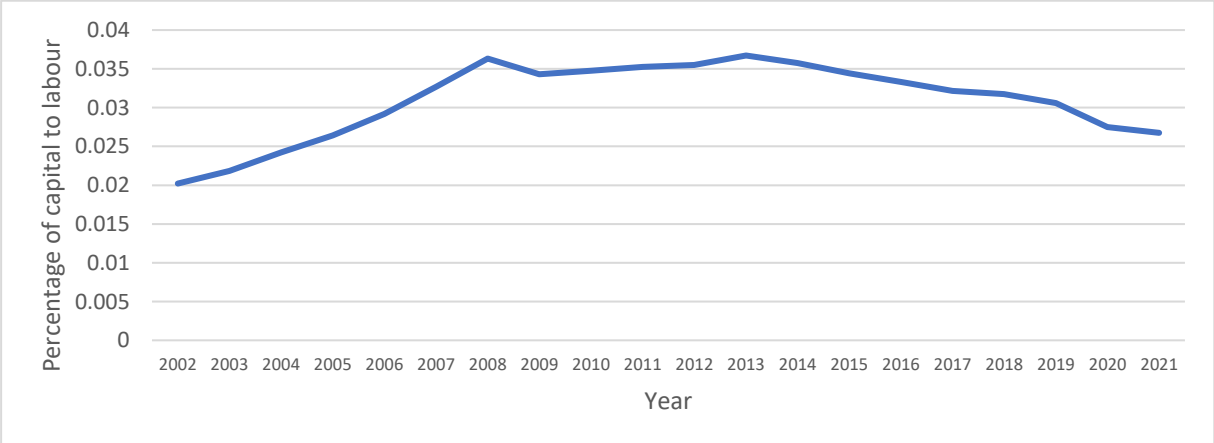

Figure 9 Capital /Labour ratio in South Africa Source: SARB (2021)

Figure 9 shows a gradual rise in South Africa's K/L ratio from 2002 to 2008, followed by a slight decline in 2009. This trend is similar to the FDI, which this study attributes to the large-scale implementation of ART programs in South Africa and Africa from the year 2000 to 2005 and the effect of the Global Financial Crisis of 2009. The rise in the K/L ratio observed in 2013 and 2014 coincides with the injection of ZAR 10,2 billion (Approximately USD 1.06 billion) into the pharmaceutical sector for the local production of antiretrovirals (ARVs). This is also the same period in which MIIT results showed specialisation in the pharmaceutical sector. Therefore, the simultaneous rise in the K/L ratio and FDI inflows potentially stimulated specialisation in the South African pharmaceutical sector in 2013 and 2014. The sharp decline in 2020 and 2021 is associated with the Global health crisis. Based on the literature that links the K/L ratio to absorptive capacity, this study examines how the fluctuations in the labour/capital ratio in South Africa (as shown in Figure 9) affect absorptive capacity in the pharmaceutical sector.

4.8 Trade barriers

Trade barriers are government-imposed restrictions that hinder international trade between countries. These barriers can manifest in various forms, including tariffs (taxes on imported goods), quotas (limits on the quantity of goods that can be imported or exported), and subsidies (financial support to domestic industries). Additional barriers include import licenses (permissions required for importing certain goods), export restraints (voluntary limits on exports), and stringent standards and regulations (health, safety, and technical requirements). Complex customs procedures and trade embargoes or sanctions (bans on trade with specific countries) also act as barriers. While these measures aim to protect domestic industries from foreign competition, preserve jobs, and ensure national security, they can also lead to trade disputes and negatively impact international economic relations.

International trade, on the other hand, is a channel through which external knowledge and technology are shared. This suggests that the more countries are open to trade, the better their chances of acquiring and adapting external knowledge and enhancing absorptive capacity. The relationship between absorptive capacity and trade policies is complex because while trade barriers can hinder absorptive capacity, some argue that they may also protect emerging industries, allowing them time to develop their capabilities (Foster-McGregor *et al*., 2014). Trade barriers have a significant influence on the ability of firms to recognize, assimilate, and apply external knowledge because these barriers can hinder the integration of foreign

technologies, particularly in emerging markets where specific challenges are prevalent (Cuervo-Cazurra & Rui, 2017). Additionally, high entry costs for firms restrict competition and innovation, further limiting absorptive capacity (Fuentes & Mies, 2021). Similarly, this study hypothesizes that countries with lower trade barriers will likely acquire more external knowledge, which they can adopt and adapt to improve their absorptive capacity. Figure 10 below shows the average percentage of trade barriers in South Africa from 2002 to 2021. The percentage reflects the duties imposed on imported goods as a proportion of their total value, indicating how much South Africa has taxed imports relative to their import prices during the study period (World Integrated Trade Solution, 2024).

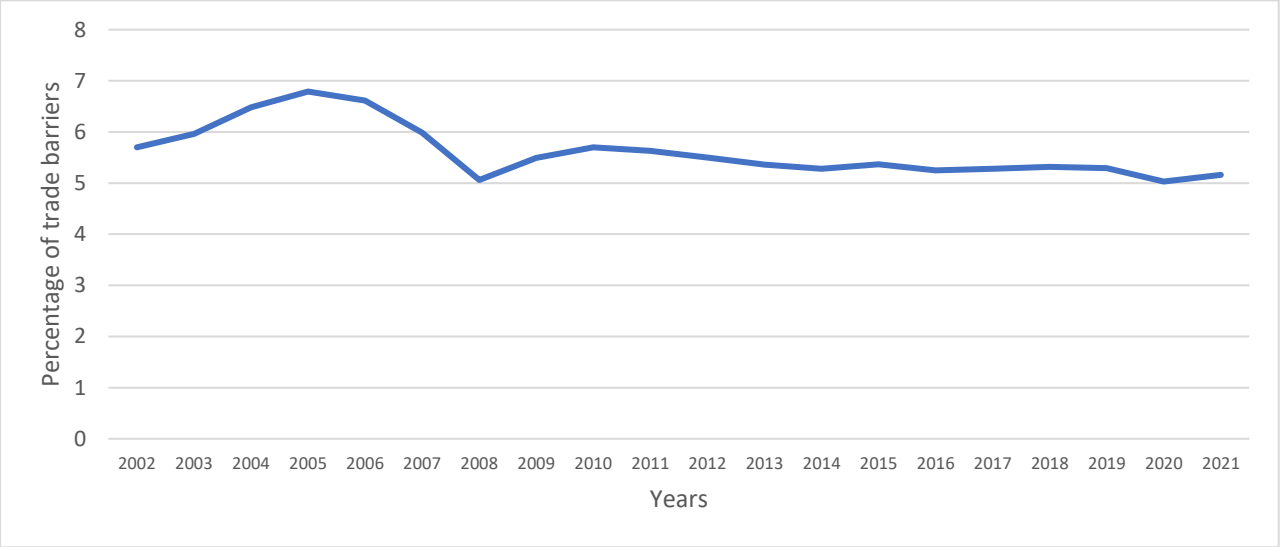

Figure 10 Average Trade Barriers in South Africa Source: World Development Indicators (2021)

Figure 10 shows a notable increase in trade barriers from 5.7 % to 6.79% between 2002 and 2005, followed by a decline from 6.61% to 5.06% between 2006 and 2008. There is a slight increase in trade barriers between 2008 and 2012, and between 2020 and 2021, which was likely driven by the Global Financial Crisis and COVID-19. This may reflect South Africa's efforts to protect domestic industries from external shocks, as governments often resort to more protectionist measures during economic downturns (Salem *et al*., 2025). Furthermore, research on global beef trade networks has demonstrated increasing regionalization, suggesting that developing countries are integrating into global trade while adopting protectionist policies to safeguard domestic markets (Qian-qian *et al*., 2025). This study will investigate how the changes observed in South Africa's trade barriers affect absorptive capacity in the South African pharmaceutical sector.

4.9 Human Development Index

The United Nations Development Programme (UNDP) designed the Human Development Index (HDI) to offer a comprehensive evaluation of a country's average accomplishments in three crucial domains: health (determined by life expectancy at birth), education (determined by mean years of schooling and expected years of schooling), and standard of living (determined by Gross National Income per capita adjusted for purchasing power parity). The HDI's primary objective is to gauge a country's overall quality of life and the welfare of the people. HDI is similar to the Human Capital Index in that it strongly emphasizes education, healthcare access, and quality of life. However, there are still debates around the issue of which components to consider to accurately measure human capital (HC). As such, Friderichs & Correa (2022) argued that a comprehensive measure of human capital in South Africa is still needed. Furthermore, the South African HC index data have too many gaps in the World Development Indicators database. Therefore, this study opted for HDI instead of the HC that previous studies like Harris & Yan (2019), Castellacci & Natera (2015), Mingyong *et al*. (2006), Keller (1995) have used.

The connection between human development and the ability to absorb knowledge and innovation is crucial to understanding how societies and organisations develop, with education being a key factor in enhancing absorptive capacity (Lane *et al*., 2006). A population with a strong educational background is more likely to possess skills like adaptability, critical thinking, and problem-solving, which makes them more effective in absorbing and applying new information. Additionally, the quality of educational institutions, professional development opportunities, and a culture of continuous learning within organizations all significantly impact absorptive capacity (Minbaeva *et al*., 2003; Todorova & Durisin, 2007). As such, some studies have used education to measure absorptive capacity (Becker *et al*., 2013; Krogstrup & Matar, 2005; Durham, 2004; Kim,1991). Figure 11 below reflects a gradually increasing HDI for South Africa from 2002 to 2021.

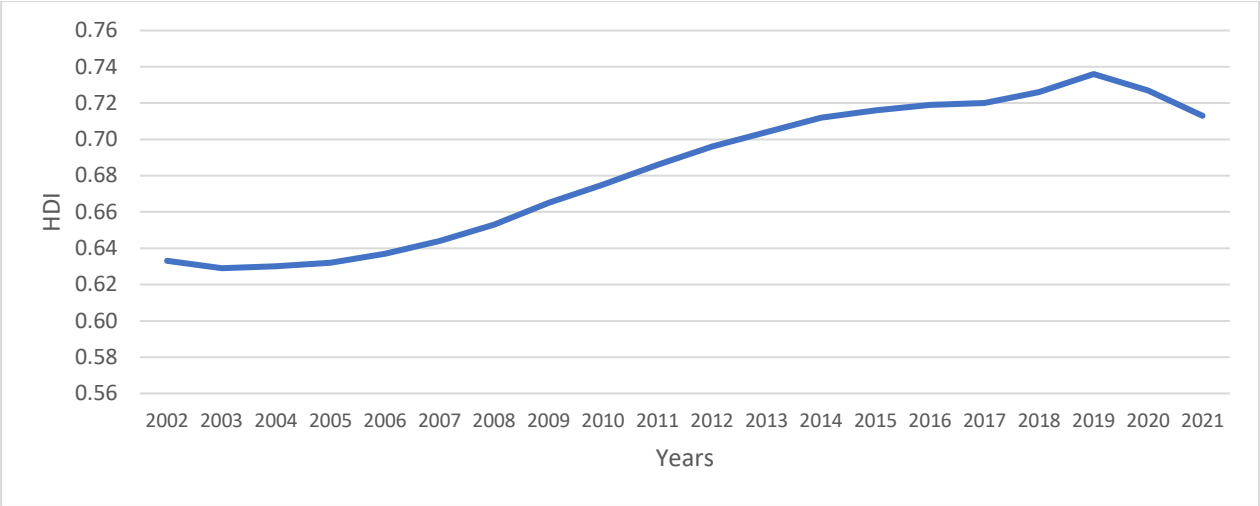

Figure 11 HDI for South Africa Source: World Development Indicators (2021)

Figure 11 depicts a gradual increase in human development for most of the study period. However, the most significant increase was observed between 2005 and 2019, reaching an all-time high of 0.74 in 2019. This could be attributed to the increased public investment in education and health, with education expenditure rising from 5.5% of GDP in 2005 to around 6.2% in 2018, and health expenditure increasing from 2.75% to 3.95% of GDP over the same period (Statistics South Africa, 2015; World Bank, 2023). These sustained investments enhanced educational attainment and life expectancy, contributing significantly to improvements in the HDI's key dimensions. The sharp drop in 2020 is the effect of COVID-19, which dropped life expectancy and negatively affected education due to the unprecedented lockdown. As such, high HDI is expected to affect absorptive capacity positively as education equips individuals with the cognitive skills necessary to acquire, assimilate, and apply new knowledge, promoting innovation and productivity growth.

4.10 Gross National Income

Gross National Income (GNI) per capita takes into account domestic production (GDP) and net income from abroad. This includes income earned by residents from foreign investments while subtracting income earned by foreigners within the country. This provides a more comprehensive measure of the income available to residents of a country, reflecting both domestic and international economic activities involving residents (OECD, 2023). Economic performance and sustainable development dynamics are crucial in understanding absorptive capacity, serving as an important indicator of an economy's size and its availability of financial resources for essential investments in infrastructure, human capital, and innovation. The significance of a higher GNI lies in its potential to indicate an economy with substantial

resources that can be strategically allocated towards research and development (R&D), education, and technological advancement, which are elements crucial for improving absorptive capacity (World Bank, 2024). Contrary to Durham (2004), who used GDP per capita, this study will use GNI as one of the indicators of absorptive capacity.

This study proposes that there is a reciprocal reinforcement mechanism between GNI and absorptive capacity. Countries with high levels of GNI equip an economy with the financial means to channel investments into education, R&D, and training initiatives, strengthening its absorptive capacity and the ability to adapt to global changes. Conversely, firms with strong absorptive capacity can mitigate risks and costs associated with innovation, leading to improved economic performance (Awwad *et al*., 2024). Figure 12 below shows the South African GNI per capita and its growth rate from 2002 to 2021.

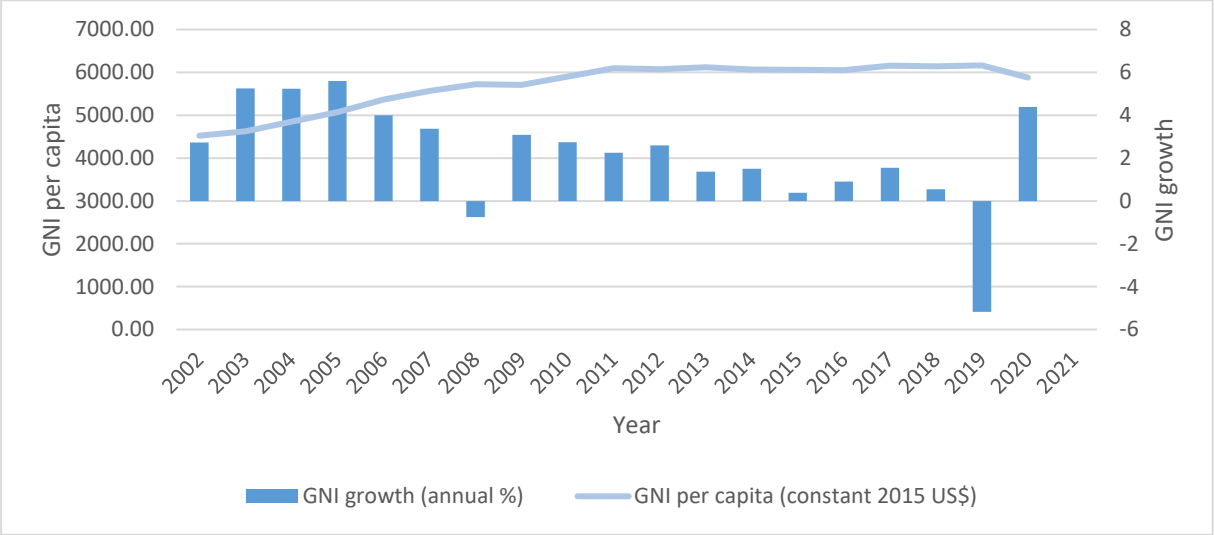

Figure 12: South Africa's GNI per Capita and GNI Annual Growth
Source: World Development Indicators (2021)

Figure 12 shows that from 2002 to 2006, a generally increasing trend in GNI growth rates fluctuated between 2.72% in 2003 and peaking at 5.60% in 2006. This was followed by a decline in GNI growth from 2007, reaching an all-time low of -5.18 % in 2020. The decline was initially due to the Global Financial Crisis and worsened by COVID-19 in 2020, followed by a rebound to 4.39% in 2021, indicating recovery efforts. However, the ability to translate economic gains into sectoral development depends significantly on the quality of institutions (Rodrik *et al*., 2004).

4.11 Quality of Institutions in South Africa

Institutions are constraints devised by humans that shape interactions between people. These constraints may be either formal or informal, and the characteristics of enforcing them shape their strength (North,1990). In general, institutional quality is a broad concept that captures law, the extent of political stability, accountability, and the quality of government regulation and services (Poniatowicz *et al*., 2020). Institutional quality is measured through six components: control of corruption, government effectiveness, the rule of law, regulatory quality, the voice of accountability, and political stability (Kaufmann *et al*., 2010). The estimates for these governance indicators range between -2.5 and +2.5, where -2.5 indicates poor governance, whereas +2.5 suggests good governance (World Bank, 2021).

Strong institutions provide a stable and predictable business environment, encouraging investments in R&D, technology adoption, and skills development. Furthermore, effective institutions facilitate transparent governance, efficient allocation of resources, and policy implementation that supports innovation and skills development (Rodrik *et al*., 2004). Contrary, weak or dysfunctional institutions characterized by corruption, bureaucracy, regulatory burdens, and policy inconsistencies can hinder absorptive capacity by creating barriers to innovation, stifling entrepreneurship, and limiting access to knowledge and resources. In such environments, businesses may struggle to adapt to technological advancements, navigate regulatory complexities, and capitalize on emerging opportunities (Duvanova, 2012).

Therefore, institutional quality is fundamental for creating an environment conducive to knowledge acquisition and utilization, which is essential for firms to adapt and thrive in competitive markets (Yao *et al*., 2020). Institutions that positively influence absorptive capacity can sustain competitive advantages by integrating external knowledge into their operations (Carvalho *et al*, 2022). Yao *et al*. (2020) further assert that while quality institutions enhance absorptive capacity, the misalignment between formal and informal institutions can hinder performance outcomes, suggesting that a nuanced understanding of institutional dynamics is essential for maximizing absorptive capacity benefits. As such, studies by Hurtado and González-Campo (2015), Becker *et al*. (2013), and Krogstrup and Matar (2005) have used institutional quality variables in measuring absorptive capacity. Table 6 presents indices for the estimates of governance indicators for South Africa as measured by the six governance components.

Table 6: The quality of institutions in South Africa from 2002 to 2021.

Control of Corruption	Government Effectiveness: Estimate	Political Stability and Absence of Violence/Terrorism: Estimate	Regulatory Quality: Estimate	Rule of Law: Estimate	Voice and Accountability: Estimate
0.33	0.61	-0.25	0.73	0.03	0.66
0.28	0.60	-0.31	0.82	0.04	0.70
0.40	0.56	-0.13	0.69	0.00	0.72
0.48	0.57	-0.16	0.72	-0.01	0.65
0.38	0.32	0.05	0.75	0.18	0.65
0.20	0.29	0.22	0.60	0.00	0.58
0.15	0.34	0.05	0.66	0.01	0.58
0.13	0.31	-0.11	0.45	0.07	0.57
0.07	0.19	-0.03	0.45	0.10	0.60
0.00	0.22	0.02	0.45	0.13	0.59
-0.18	0.17	-0.03	0.40	0.08	0.58
-0.14	0.31	-0.05	0.38	0.14	0.60
-0.12	0.16	-0.15	0.23	0.16	0.64
-0.04	0.12	-0.21	0.22	0.04	0.65
0.04	0.13	-0.14	0.13	0.06	0.65
-0.10	0.10	-0.28	0.15	-0.14	0.63
-0.11	0.13	-0.23	-0.03	-0.20	0.63
0.02	0.16	-0.27	0.02	-0.12	0.65
-0.01	0.10	-0.24	0.04	-0.18	0.70
0.02	-0.02	-0.71	-0.07	0.13	0.79

Source: Worldwide Governance Indicators- World Bank (2021)

Table 6 shows that South Africa's governance is generally rated very low across all components. Studies have shown that countries with weak legal systems and rampant corruption struggle to instill confidence in investors, negatively impacting the inflow of foreign capital and disrupting economic growth (Atlantic Council, 2022). In particular, political stability and control of corruption are sometimes below zero. Weak institutions reduce investment confidence, deter innovation, and inflate operational costs through inefficiencies and corruption (Imam *et al*., 2024). They also pose barriers to international trade, impair public-private partnerships essential for addressing public health challenges, and limit access to affordable financing by increasing country risk. Addressing these governance issues is critical to creating a stable and conducive environment for growth and competitiveness in the South African Pharmaceutical sector.

4.12 The Conceptual Framework of the Determinants of Absorptive Capacity

Based on the reviewed literature, the determinants of absorptive capacity in the South African pharmaceutical sector can be visualized as follows:

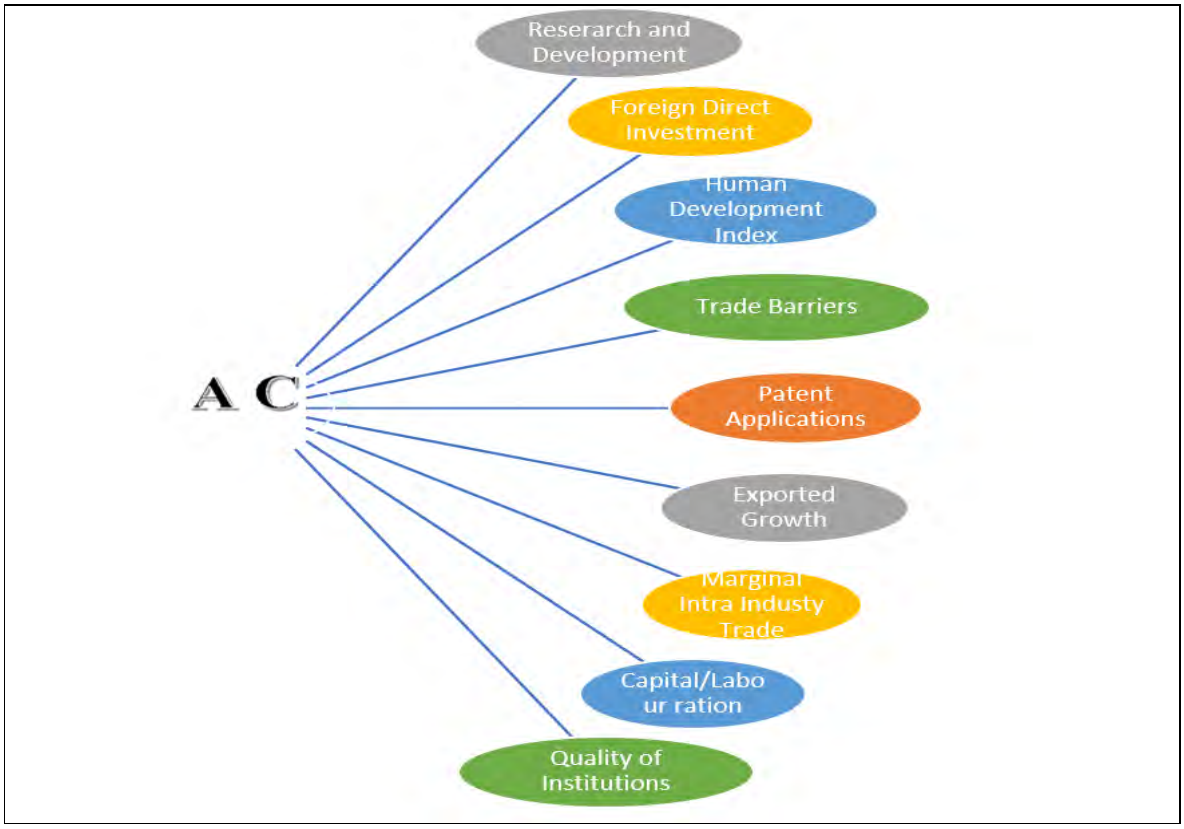

Figure 13: The Conceptual Framework of Absorptive Capacity in the South African Pharmaceutical Sector
Source: Author's computation based on literature

4.13 Summary and Conclusion

This chapter examined the factors affecting absorptive capacity by analysing their trends and how they will likely affect firms' ability to absorb and integrate external knowledge into their production process. The most glaring feature in most trends was the effect of major shocks like the Global Financial Crisis and COVID-19. While the trends of some factors, such as the Human Development Index, Gross National Income, and K/L ratio, remained relatively steady for most of the studied period, some trends raised concerns. For instance, the analysis showed that intra-industry trade, the value of pharmaceutical exports, FDI inflow, the quality of institutions, and patent applications by South African residents were generally low. The low levels of these variables imply that the country faces challenges in acquiring, assimilating, transforming, and exploiting external knowledge into competitive products. Improving intra-industry trade, attracting more FDI, and strengthening institutional quality would be crucial to building a more robust and innovative pharmaceutical sector capable of absorbing and applying

global knowledge for sustained growth. The next chapter deals with the first objective of this study, which is to examine intra-industry trade in the pharmaceutical sector and the key factors for improving it. This study considers Intra-industry trade as an important channel through which countries or firms acquire external knowledge to boost their absorptive capacity.

Chapter 5
Measuring Intra-Industry Trade and Productivity in the South African Pharmaceutical Sector [8]

5.1 Introduction

South Africa is Africa's largest pharmaceutical producer, with a market size of $3.9 billion. The industry includes about 128 companies, with key players like Aspen Pharmacare and Adcock Ingram (Phillips, 2023; African Pharmaceutical Analysis Report, 2021). As shown in Chapter 2, Aspen, Adcock Ingram, Cipla, Sanofi, and Novartis are the leading pharmaceutical firms in South Africa based on their supply of scheduled and non-scheduled medicines for prescribed and over-the-counter medication. These companies are involved in various stages of the pharmaceutical supply chain, including Research and Development, manufacturing, marketing, and distribution. The South African pharmaceutical sector is an important contributor to the country's economy and significantly contributes to the Southern African region's healthcare landscape. However, the industry heavily depends on imports to meet some of its needs, particularly for high-tech and patented products. Local manufacturers of pharmaceutical products rely heavily on the imports of Active Pharmaceutical Ingredients (APIs). Some studies that examined the South African pharmaceutical sector found that it largely depends on imported products (Veitch, 2020; Rayment, 2020; Viviers *et al*., 2014; Te Naudé & Luiz, 2013; and Maloney & Segal, 2007). While imports may benefit the country by providing access to a wide variety of products, among other things, heavy dependency on imports comes with a number of problems.

First, the prices for medicines and other pharmaceutical products increase because most South African manufacturers depend on imported APIs and other raw materials to manufacture their products. Importing raw materials and the weaker Rand (local currency) lead to manufacturers selling at higher prices, which many people struggle to afford. The Consumer Price Index (CPI) for medicinal products in South Africa was measured at 110.5 points regarding medical products. As Figure 3 in Chapter 2 shows, this is an increase of 6.5 points from the previous prices over a period of 4 years (Statistica, 2023). The problem of unaffordable quality medicines does not only affect South Africa but other Southern African countries that depend on South Africa for pharmaceutical supplies, considering that a significant percentage ranging from

[8] A more condensed version of this chapter was published as an original research article by the South African Journal of Economic and Management Sciences (SAJEMS) on 05 August 2024. Available online at https://sajems.org/index.php/sajems/article/view/5486

27.6% up to 73.6% of South Africa's pharmaceutical exports (Table 4, Appendix B) go to the Southern African Development Community (SADC). As a result, healthcare affordability and access to high-quality medicines for all citizens have been a critical government priority in South Africa since the end of apartheid in 1994 (Moodley & Suleman, 2019). However, this goal has not been achieved so far.

Second, the pharmaceutical sector constitutes a significant part of the economy (estimated at $3.9 billion). As such, the increasing pharmaceutical trade deficit (Table 4, Appendix B) negatively affects the country's economy by draining foreign exchange reserves and stifling economic growth and the capacity to create jobs. Therefore, policymakers and industry stakeholders need to monitor and address the issue of import dependence to ensure sustainable growth and competitiveness in the industry. As such, local medicines manufacturing is strategically important for the South African government (Veitch, 2020).

Third, depending on imported pharmaceuticals further exposes society to low-quality and counterfeit products as manufacturing standards and quality control measures vary from one country to another. Counterfeit products are often sold at a lower price than legitimate medicinal products, which attracts consumers who seek cheaper alternatives. As such, the South African Health Products Regulating Authority (SAHPRA) has recalled some medicines from May 2021 to August 2023 (Table 3, Appendix A).

Fourth, domestic firms struggle to compete with foreign firms, leading to declining domestic manufacturing. In South Africa, this trajectory is evidenced by the closure of an estimated nine plants in the late 1990s because more companies opted to import rather than produce (Table 2, Chapter 2). On a global scale, the South African pharmaceutical sector is positioned as an end market for selling products produced elsewhere through the global value chain (GVC) rather than as a manufacturing site (Horner, 2021). As such, South Africa should carefully manage its trade relationships in this sector and balance imports and exports to maintain a certain level of domestic production and self-reliance.

To this end, this study argues that intra-industry trade plays a crucial role in the growth and sustainability of the South African pharmaceutical sector. This type of trade promotes knowledge acquisition from external sources and drives innovation and technological advancement, leading to increased local production, expanded export opportunities, and

reduced dependence on imports. Accordingly, the National Industrial Policy Framework (Strategic Program 3:9.6) acknowledges export promotion as vital for creating employment and reducing current account deficits while emphasising the need to identify and consider export constraints (National Industrial Policy Framework, 2014). Moreover, the COVID-19 outbreak has emphasized the need for African countries to enhance local and regional production abilities for various manufactured goods, particularly in the pharmaceutical sector. This chapter primarily aims to examine the trade pattern between South Africa and its trading partners in the pharmaceutical industry and measure the level of intra-sectoral trade. The results will reveal the level of intra-industry trade and the direction of trade specialisation, which has implications for the flow of factors of production in the South African pharmaceutical sector.

Intra-industry trade has been a subject of contention for many years. Scholars acknowledge that such trade has become increasingly recognizable in international trade and is a significant part of trade. Nevertheless, intra-industry trade is primarily associated with high and middle-income countries, while African trade remains overwhelmingly inter-industry (Brülhart *et al*., 2006). As a result, studies that examined intra-industry trade in the African context are limited. However, there is evidence that some trade in developing countries is also intra-industry (Manrique, 1987). The few studies that investigated intra-industry trade in South Africa include the unpublished study by Simson (1987), Parr (2000), Isemonger (2000), Al-Mawali (2005), and Sichei *et al*. (2007). Noteworthy, these studies were carried out before economic crises like the 2008 global financial crisis, the Eurozone financial crisis, the COVID-19 pandemic, and recovery. Also, rapid technological advancement, numerous trade agreements, policy shifts, and the rise of emerging markets like China and India are all factors that may have reshaped trade relationships and are not captured by these studies. Furthermore, none of the studies analysed intra-industry trade within a specific industry. A more comprehensive understanding can be derived from a detailed examination of an individual industry, considering its distinctive institutional structures and global standing, which directly affects its trade performance.

If most of the trade growth is intra-industry (IIT), then industries benefit from lower adjustment costs as the disruption to factor markets is likely to be minimal during trade expansion because each industry produces differentiated varieties, which have similar factor requirements (Menon & Dixon, 1997; Greenaway *et al*.,1995; Brülhart, 1994; Hamilton & Kniest, 1991; Helpman & Krugman, 1985 and Helpman, 1981). Moreover, intra-industry trade may stimulate innovation, increase investment in knowledge-based capital, facilitate joint research, and increase

specialisation. All these benefits would further intra-industry trade, leading to increased productivity, industrial expansion and depth, and industrial performance. This implies that industries that engage in intra-industry trade are less prone to substantial adjustment costs like retraining workers, upgrading technology or infrastructure, relocating to a new area, or complying with new regulations. These costs may decrease profits for firms in the short run, potentially restricting new firms from entering the market. Consequently, the level of local manufacturing decreases while the appetite to source cheap imports increases. High adjustment costs perpetuate dependence on imported products and increase the industry's vulnerability to external shocks. Therefore, the South African pharmaceutical sector would benefit from intensifying intra-industry trade.

Based on the general view in the literature concerning the nature of trade in developing countries, the study expects trade in the South African pharmaceutical sector to be significantly inter-industry[9]. Therefore, the second fold of this study investigates the key factors for improving intra-industry trade. The question then becomes, "What factors play a vital role in enhancing intra-industry trade in the South African pharmaceutical industry?" The point of departure on this subject is that there are low pharmaceutical exports compared to imports in South Africa. As such, local pharmaceutical production and exports must improve to enhance intra-industry trade. Increased local production and exports can be achieved by improving productivity in the sector.

The nexus between productivity and export growth is well documented in the literature. One strand of the literature views outward-oriented trade regimes as a source of productivity gains (Benguria *et al.,* 2022*;* Hatemi & Irandoust, 2001; Chen & Tang, 1990). Another strand contends that high productivity increases the likelihood for firms to export if they are larger and if they benefit from foreign networks, domestic networks, and communication networks (Ricci & Trionfetti, 2012; Bernard & Jensen, 2004; Aitken *et al*., 1997; and Roberts & Tybout, 1997). Total Factor Productivity (TFP) is commonly used to measure firms' productivity. Furthermore, effective economic and business policy-making requires precise measurement of TFP change and its components (O'Donnell, 2012). For this reason, this chapter empirically analyses TFP to determine the factors influencing productivity to boost exports in the South African

[9] Inter-industry trade refers to the exchange of goods and services between countries that belong to different industries or sectors.

pharmaceutical sector. The aim is to see more pharmaceutical exports match imports to increase intra-industry trade.

The importance of this analysis is based on three reasons. First, it aligns with the primary objective of the 15-year Pharmaceutical Manufacturing Plan for Africa (PMPA), spanning from 2013-2028. The plan aims to support local pharmaceutical manufacturing to enhance access to affordable, quality medicines and establish a sustainable supply chain for essential medicines (AUC-UNIDO, 2012). Second, it also aligns with the Sustainable Development Goals 2030 (SDG, 2030), which focuses on boosting the share of global exports for developing nations. Lastly, this chapter contributes to the literature on intra-industry trade in developing countries by showing the correlation between an improvement in TFP and an increase in intra-industry trade necessary to stimulate domestic production to reduce high import demand. The following sections discuss the theoretical framework, methodology, and analysis of results.

5.2 Theoretical framework

Initial research on international trade sought to explain the economic benefits associated with countries that trade with one another. The theory of comparative advantage introduced by David Ricardo in 1821 was the primary reference for this purpose. The Ricardian theory emphasised the importance of having a different comparative advantage in trading countries for trade to be beneficial. However, the theory of comparative advantage failed to explain why production conditions differ between countries, an issue that Heckscher (1919) and Ohlin (1933) attributed to differing factor endowments.

In contrast to the supply-side orientation of the Heckscher and Ohlin model, Linder (1961) predicted that trade is a product of "overlapping demand." This theory suggests that countries produce goods for their domestic market and export the surplus. As such, Linder concluded that countries interested in purchasing this surplus would have demand patterns similar to those of the exporting country. Linder's prediction that most trade in the world should occur between similarly endowed countries is no paradox; it is, instead, the natural result of a demand-driven trade.

To some extent, traditional trade theories still hold in today's world. However, it has been observed that trade between countries with similar economies has significantly increased over the years. Studies of international trade reached a consensus that trade has evolved from inter-

industry to more intra-industry trade. Subsequently, scholars examined intra-industry trade to determine if its underpinnings align with the existing trade theories. Differing conclusions have been reached in this regard, with some maintaining that intra-industry trade can be viewed through the lenses of comparative advantage and factor endowment theories (Ddudovkiy, 2012; Brülhart, 2008; Ruffin, 1999; Davis, 1995; Helpman, 1981; Finger, 1975). In contrast, others criticised the traditional theories for inadequately explaining the new trade patterns (Kierzkowski, 1987; Greenaway & Milner, 1983; Krugman, 1981; Falvey, 1981; Gray, 1976). The main criticism is that the comparative advantage and factor-endowment theories fail to explain significant volumes of trade between countries with similar factor endowments and technology and to capture the role of product differentiation and economies of scale. As such, Eaton and Kierzkowski (1984), Helpman (1981), Lancaster (1980), and Krugman (1979, 1981) pioneered the groundwork in the field of intra-industry trade.

Subsequently, large volumes of scholarly work have been produced to shed light on the importance, measurement, and determinants of intra-industry trade. The literature highlights lower adjustment costs as the main benefit of intra-industry trade because an increase in intra-industry rather than inter-industry trade enables a simple adaptation to trade growth (Menon & Dixon, 1997:164; Greenaway & Milner, 1983). In terms of measurement, it is essential to measure intra-industry trade as accurately as possible to test any newly developed models of intra-industry trade. As such, the Grubel-Lloyd (1975) index has been widely used as a standard measure of intra-industry trade. However, the Grubel-Lloyd index has been met with severe criticisms, leading to the development of alternative models discussed in the method section below.

As Lancaster (1976) introduced it, Paul Krugman's New Trade Theory revolutionised the field of international trade economics. Lancaster (1976) argued that under perfect monopolistic competition, firms have some market power and can produce various differentiated products, leading to intra-industry trade between countries. The central concepts in Lancaster's theory are "product space" and "product characteristics." On the one hand, product space implies that products can be arranged in a multi-dimensional product space based on various characteristics such as quality, design, and brand. Countries with similar preferences and abilities will trade products close in this space.

On the other hand, product characteristics within each category imply that products can be distinguished by their characteristics, and consumers may have preferences for specific attributes. For instance, automobiles can differ in size, fuel efficiency, or safety features. These differences provide a premise for trade within the industry because it would not make sense for a country to import a good identical to what is produced domestically. Product differentiation and imperfect competition have been bases for repeatedly attesting and justifying intra-industry trade as a new approach to international trade (Fontagné *et al*., 2005). For example, the South African pharmaceutical industry is characterised by a broad range of products, including branded drugs, generics, and specialized treatments, each varying in formulation, efficacy, and market targeting, driven by significant R&D investments and regulatory requirements that enforce product uniqueness. Furthermore, the South African pharmaceutical market is oligopolistic, dominated by a few firms with substantial market power, high entry barriers, and prevalent mergers and acquisitions, all contributing to an imperfect competitive environment. These factors create a landscape where the exchange of differentiated products is common, such as South Africa importing innovative drugs while exporting generics. Therefore, it is reasonable to assume that Lancaster (1979) provides a theoretical framework underpinning this study, just as Krugman (1979, 1980, and 1984) used the same framework in his analysis of intra-industry trade.

5.3 Methodology

5.3.1 Measuring Marginal Intra-Industry Trade

The degree of intra-industry trade (IIT) in the South African pharmaceutical sector was measured using 1-digit SITC data from the United Nations Conference On Trade And Development (UNCTAD) databases from 2002-2021, available online at https://unctad.org. The period studied is critical for pharmaceutical trade because (i) it is when South Africa entered into deeper trade agreements with notable global pharmaceutical producers like India and China; (ii)South Africa implemented major policy changes in the Department of Health like introducing the Single Exit Price (SEP) and the massive rollout of Antiretroviral Therapy (ART) in 2003. (iii) This period is characterised by the adoption of the Fourth Industrial Revolution (4IR), which saw the integration of automation into the manufacturing processes. (iv) Pre and post-COVID-19 pandemic also fall within this period. All these factors potentially affected the pattern of the pharmaceutical trade.

The Grubel-Lloyd Index (GL*i*) is the standard measure of intra-industry trade between countries. However, Lee (2004) criticised the index for being fundamentally flawed and lacking theoretical foundations. The Grubel Lloyd index was criticised for neglecting the adjustment cost aspect. Hence, the introduction of the *marginal* intra-industry trade (MIIT), which measures the degree of IIT in *new* trade, became an alternative to the Grubel-Lloyd Index (Hamilton & Kniest, 1991; Brülhart, 1994, 1999; Greenaway *et al*., 1994; Parr, 2000).

Hamilton and Kniest (1991: 360) proposed the original Marginal Intra-Industry Trade, which calculates the percentage rise in matched exports and imports. It has been found to have certain limitations, leading to a discussion on an appropriate measure (Cattaneo & Fryer, 2002). Greenaway and Torstensson (1997: 253) highlighted the primary drawbacks of the Hamilton-Kniest measure, represented by dX/dM if dM> dX> 0 and dM/dX if dX > dM > 0.32. First, if there is a decrease in imports or exports, the MIIT index is undefined. Second, the measure is unscaled (also a major limitation of the Grubel-Lloyd index): It does not refer to the actual amount of new trade, nor to the initial level of trade or production within that specific sector. Lastly, the changes in trade were measured in nominal rather than absolute terms, and this criticism would apply to any MIIT index (Cattaneo & Fryer, 2002).

Brülhart (1994) and Greenaway *et al.* (1994) developed many alternative measures of MIIT to correct the limitations of the Hamilton-Kniest measure. This study will use the Marginal Intra-Industry Trade (MITT) index proposed by Brülhart (1994) because it provides a more nuanced understanding of how trade patterns evolve. For example, it allows one to differentiate the adjustment in intra- or inter-industry trade that is taking place.

Brülhart's basic measure of matched changes is as follows:

$$MIIT = \frac{(dX_i - dM_i)}{(|dX_i| + |dM_i|)} \quad (1)$$

Where, dX_i is industry i's change in exports and $dM_i$is industry i's change in imports. Then $(dX_i - dM_i)$ represents the net value of new trade and $(|dX_i| + |dM_i|)$ represents the absolute value of total new trade. The value ranges from -1 to 1. Matched (intra-industry) trade is indicated by MIIT= 0, which means that the new trade is dXi = dMi. Unmatched (inter-industry) trade is indicated by the value of MIIT between 0 and -1, which means that new trade is dXi

<dMi and that the country has specialised out of the industry (Cattaneo & Fryer, 2002). Lastly, if dXi > dMi, and MIIT is between 0 and 1, it implies that the new trade is more inter-industry or unmatched. However, the country has developed a specialisation in that industry (Parr, 2000). The sign of the index is helpful to indicate the direction of specialisation in individual sectors (i.e., into or out of the sector). In contrast, its size signifies the degree to which new trade is matched or unmatched relative to the total change in trade. For instance, an MIIT value of -1 signifies that marginal trade is unmatched and the country is specialising out of that particular sector (Cattaneo & Fryer, 2002).

While any deviation of MIIT from zero indicates some level of inter-industry specialisation, choosing a threshold between significant intra-industry changes and notable inter-industry specialisation into or out of the industry is important. Following Parr's approach, this study selects critical MIIT values of +/-0.65 (Parr's 2000, p. 302). This means that a value of MIIT ranging from -1 to -0.65 indicates specialisation out of the industry; MIIT from -0.65 to 0.65 indicates significant intra-industry changes have taken place; and MIIT from 0.65 to 1 indicates that there has been specialisation into that industry.

As Cattaneo & Fryer (2002) point out, it is important to incorporate a qualification when selecting a suitable index for examining adjustment costs concerning intra-industry trade. Menon & Dixon (1997, p. 164) contend that the focal point should be measuring new inter-industry or unmatched trade, typically treated merely as a residual component. They propose utilising unmatched changes in trade (UMCIT) measures, asserting its greater suitability for research focused on adjustment costs. Unlike MIIT, UMCIT can quantify the extent of trade changes necessitating inter-industry factor adjustments and is measured as follows:

$$UMCIT=|\Delta X_i - \Delta M_i| \quad (2)$$

Despite the weak correlation that Menon & Dixon (1997) found between unmatched and matched measures of intra-industry trade, more evidence can be obtained by using both MIIT and UMCIT to analyse changing trade flows in the South African pharmaceutical sector.

5.3.2 Measuring Total Factor Productivity

As mentioned earlier, the study anticipates that trade is predominantly inter-industry. Consequently, exploring strategies to strengthen intra-industry trade within the pharmaceutical

sector is essential for increasing export potential, improving trade balance, and reducing dependence on international supplies. One strategy is measuring productivity change in the pharmaceutical sector with a specific focus on factors that influence change in productivity using data from the South African Reserve Bank and UMCIT values (as explained in the section measuring MIIT above) for 2002-2021. This study's fundamental premise is that individual firms operating in the pharmaceutical manufacturing sector aim to maximise their output. In this case, the output is represented by the value of finished pharmaceutical products ready for consumption and exporting. These products are assumed to be produced within the constraints of the firms' available inputs and production technology.

Based on the view that productive firms are more likely to export (Ricci & Trionfetti, 2012; Aitken *et al*., 1997; Roberts & Tybout, 1997; Bernard & Jensen, 2004), the logic followed in this study is that if firms' productivity increases, exports will increase and more trade will be matched. On the contrary, if firms' productivity declines, exports will decrease, and more trade will be unmatched. This analogy makes the UMCIT eligible as an output variable in measuring productivity change. Research and Development (R&D), Foreign Direct Investment (FDI), Real Capital Formation, and Labour, were used as the input variables. R&D drives productivity by fostering innovation, enhancing capabilities, and providing competitive advantages. While there are challenges associated with R&D investments, the long-term benefits to productivity and economic growth are substantial (Blanco & Prieger, 2016; Griliches, 1998). Foreign Direct Investment (FDI) drives economic growth, especially for developing nations, offering technological access and positive spillover effects (Liu *et al*., 2016; Liu *et al*., 2001). Adequate capital input boosts labor productivity, and improvements in labor quality and utilization lead to higher productivity and economic growth. Understanding and enhancing the role of labor is crucial for increasing total factor productivity (Jajri & Ismail, 2018). Therefore, this study employs an output-oriented approach to evaluate alterations in TFP, where TFP is defined as the ratio of total outputs to total inputs (Marire, 2020). Notably, the primary concern of this paper is not to measure the absolute level of productivity but the dynamic changes in productivity over time, which will then influence the intra-industry trade that the UMCIT also represents.

The study utilises a TFP index to quantify the shifts in TFP using the Malmquist index, which facilitates the comparison of TFP changes between consecutive periods while accounting for any shifts in the typical production technology (Balk, 2013; Coelli *et al*., 2005). This framework

enables us to assess how efficiently pharmaceutical manufacturing firms utilise their resources and how their productivity evolves.

The Data Envelopment Analysis (DEA) has been widely used in the studies of productivity and efficiency to analyse changes in Total Factor Productivity. Cooper *et al.* (2011) describe the DEA as a 'data-oriented' mathematical programming technique used for evaluating the performance of a set of peer entities called Decision-Making Units (DMU). The DEA involves using linear programming methods to construct a non-parametric piecewise surface (or frontier) over the data to calculate efficiency in relation to this surface (Coelli *et al*., 2005). The DEA determines efficient levels of inputs and outputs for the organisation under evaluation by computing a scalar measure of efficiency. This study used the Malmquist Total Factor Productivity (MTFP) index to examine the factors that influence TFP changes in the pharmaceutical industry because it allows us to assess how efficiency and production technology evolve. The MTFP index makes it possible to measure the improvement or decline in efficiency and the underlying production technology. This index provides a dynamic process for analysing changes in efficiency and productivity, and it determines the underlying factors driving these changes by decomposing the Malmquist TFP index. The key components of productivity change include technical change, technical efficiency change, and scale efficiency change (O'Donnell, 2012).

As in Marire (2020), Figure 14 offers a simplified representation of what production theory considers when assessing changes in productivity and efficiency. The graph assumes constant returns to scale, meaning that outputs increase proportionally to the increased inputs.

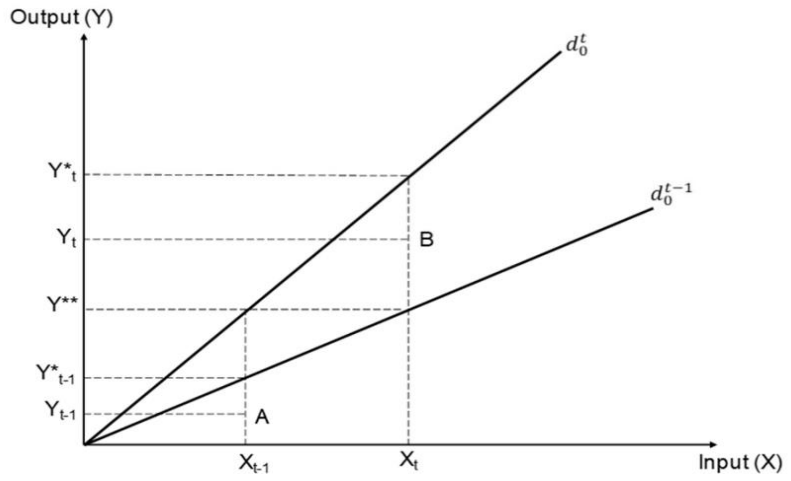

Figure 14: Output distance functions and measurement of productivity change

Figure 14 illustrates output distance functions and the measurement of productivity change. In this figure, d_0^{t-1} and d_0^t represent the production functions or technologies for periods t-1 and t, respectively. The decision-making unit operates below its technological frontier in both periods, situated at point A in period t-1 and point B in period t, indicating inefficiency. Performance measurement studies have identified various factors that contribute to improving TFP growth.

Firstly, technical change indicates a shift in production technology, such as an expansion or contraction of the maximal outputs or the production frontier (Coelli *et al*., 2005). In Figure 14, this is depicted as a transition from d_0^{t-1} to d_0^t or from d_0^t to d_0^{t-1}, and it is typically a product of innovation (Kaplan, 1999). As Jakovljevic (2018) points out, innovative organisations consistently undergo cycles of technical change.

Secondly, there is technical efficiency change, where the producer approaches or moves farther away from the existing production frontier (Coelli *et al*., 2005). Figure 14 illustrates this movement as a shift from point A toward d_0^{t-1} in period t-1 and from point B toward d_0^t in period t. Thirdly, scale efficiency change occurs when the producer enhances productivity by adjusting the scale of operations to achieve a technologically optimal scale (Balk, 2001). Figure 2 relates to the ability to produce the same or more output with fewer resources. For instance, producing Y** on d_0^t with input level X_{t-1}, which is less than X_t (the input level required on d_0^{t-1}), demonstrates scale efficiency change. Lastly, the output mix effect refers to improving productivity by altering the combination of outputs (Balk, 2001; Coelli *et al*., 2005). This change in the output mix impacts scale efficiency. The conventional procedure combines these sources of productivity change to yield the Malmquist total factor productivity change (TFPC) (Coelli *et al*. 2005). The relationship can be stated as:

$TFPC^{t-1,t}(X_{t-1},X_t,Y_{t-1},Y_t)$ = *technical change * technical efficiency change* scale efficiency change*output mix effect* (3)

X_{t-1} represents a set of input factors employed to generate a set of outputs Y_{t-1} during the preceding period (t-1), while X_t signifies the input vector employed in producing a set of outputs (Y_t) in the current period (t). Every element within Equation 3 is derived from an index, and each of these elements was estimated by decompositions of equations (4) to (7) (Appendix E). This measurement can take the form of one (indicating an increase in the output mix effect),

less than one (suggesting a decrease in the output mix effect), or exactly one (indicating no change in the output mix). The paper employed the decomposition framework represented in Equations (4) to (7) to assess changes in total factor productivity in the pharmaceutical manufacturing context.

UMCIT was used as an output variable instead of the MIIT index because the DEA program does not recognize ratios. The program combines all the variables and classifies them into productive efficiency, scale efficiency, technical efficiency, and Total Factor Productivity changes. TFP is regarded as the output, while other variables are regarded as inputs that influence TFP changes.

5.4 Analysis of Results

5.4.1 Intra-Industry Trade Results

The results from analysing trade in the South African pharmaceutical sector suggest that new trade is largely inter-industry because MIIT values deviate from zero. This is consistent with early literature on Intra-industry trade, which asserted that trade in Africa is overwhelmingly inter-industry (Brülhart *et al*., 2006; Havrylyshyn & Civan, 1985). MIIT index further reveals that a significant share of trade specialisation in South Africa is outside the pharmaceutical industry because MIIT values are mainly negative (Table 5, Appendix G). Similarly, the UMCIT results (Table 6, Appendix H) show significant volumes of unmatched new trade as shown by high UMCIT values, which supports the MIIT results and confirms the *a priori* expectation (that trade is inter-industry) of this study. This means that a wider range of products within the pharmaceutical industry is imported while a narrower range is exported. Specialising out of the industry also implies that resources will be allocated towards products with a more competitive edge than pharmaceuticals. Nevertheless, the results revealed some important nuances that could provide a basis for relevant interventions to help achieve a balanced pharmaceutical trade. Figure 15[10] below provides the trend of the MIIT and UMCIT results.

[10] This is the same as Figure 4 in Chapter 4, however, it is presented again for ease of reference and for a more comprehensive discussion.

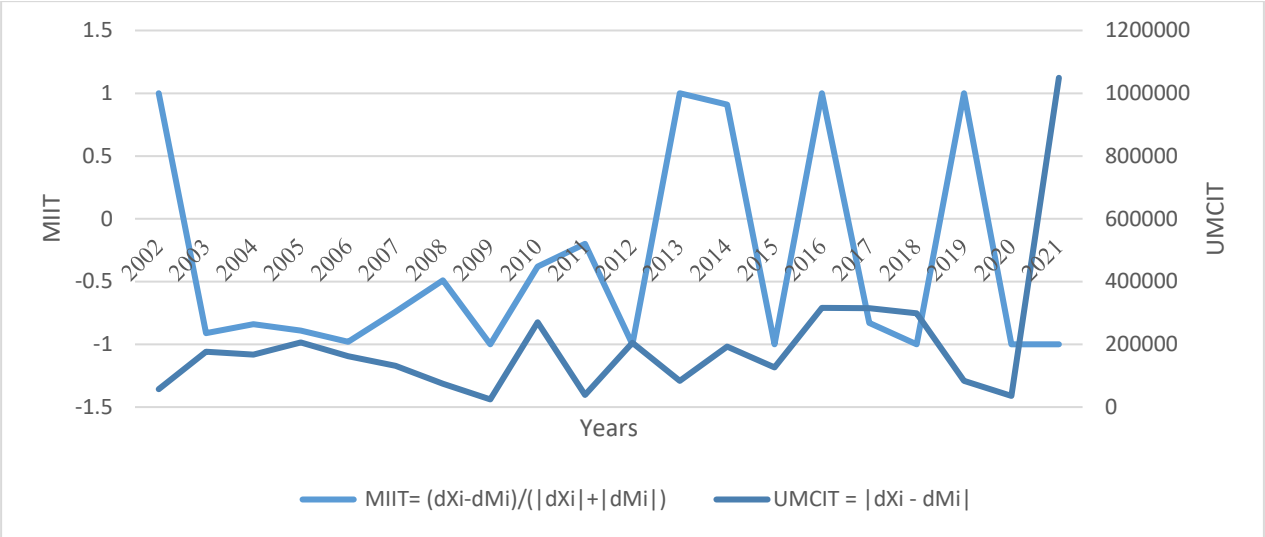

Figure 15. The trend of MIIT and UMCIT in the South African pharmaceutical sector

The first finding is that although new trade is largely inter-industry, there are periods of specialisation in the industry shown by positive MIIT values (implying that new trade is more inter-industry); however, the country has developed a specialisation in that industry for 2002, 2013, 2014, 2016, and 2019. Specialisation is associated with several benefits, which include increased efficiency, fostering innovation, cost-saving production (benefits from economies of scale), and skills development. It may also increase export opportunities and partnerships. Therefore, the industry should sustain the state of specialisation observed in 2002, 2013, 2014, 2016, and 2019 to enjoy the benefits associated with it.

The second finding is that there were periods of significant intra-industry trade (because MIIT values range from -0.65 to 0.65) changes despite trade specialisation being predominantly outside the industry (Table 5, Appendix G on comments considering critical values). Table 5 shows significant intra-industry changes during 2008, 2010, and 2011 because the MIIT values fall between -0.65 and 0.65 for those years. Similarly, Kandogan (2003) found that Intra-Industry trade takes only a small portion of trade with developing countries. Significant Intra-industry trade was due to exports increasing more than exports, as shown in Table 7 below.

Table 7: Analysis of significant intra-industry changes

Years	PERCENTAGE CHANGE IN PHARM. EXPORTS	PERCENTAGE CHANGE IN PHARM. IMPORTS
2007-2008	24.59%	7%
2009-2010	112,4%	28%
2010-2011	53%	19%

Source: Author's own computation

On all three occasions when significant intra-industry changes were observed, exports grew at a higher percentage than imports. Although these changes occurred occasionally, they indicate that South Africa holds a certain level of competitive advantage in producing some pharmaceutical products. However, finding out which products are competitive will require further research in order to help the firms producing those products strengthen their comparative advantage further.

Several underlying factors contributed to the MIIT results presented in Figure 3 above. The following points attempt to shed light on possible underlying causes for the results. First, the industry specialisation in 2002 (MIIT=1) could be a product of the strategic plan for addressing HIV/AIDS in South Africa. The years 2000 to 2005 marked the first decade of implementing the antiretroviral therapy (ART) program in South Africa and Africa at large, making significant progress in providing life-saving treatment for HIV/AIDS patients. According to the report by the Joint Health and Treasury Task Team (2003), the cabinet reaffirmed its dedication to the strategic plan for addressing HIV/AIDS and STIs in South Africa, 2000-2005. South Africa's antiretroviral (ARV) program is the largest globally, and the country is one of the world's major producers of radiopharmaceuticals (Veitch, 2020). The massive rollout of the therapy started in 2003, suggesting that a bulk of the manufacturing activities occurred in the previous year, as evidenced by industry specialisation in 2002.

Second, the extensive period of specialisation outside of the industry from 2003 to 2012 may be partially attributed to the implementation of the Single Exit Price (SEP). The introduction of SEP for medicines in South Africa was a significant regulatory change aimed at price

transparency of medicines and making them more affordable. However, implementing SEP had unintended consequences as pharmaceutical manufacturers experienced decreasing profits. SEP increases are insufficient to offset the effect of a weaker Rand (Local currency) and year-on-year inflation since most companies import APIs and other raw materials from overseas (Naidoo & Suleman, 2021). The weakening of the Rand in a price-controlled environment increases the cost of production for goods sold (PMG, 2017; Ngozwana, 2016). Higher production costs decrease the products' global competitive edge and reduce the incentive to invest in local production. As a result, some pharmaceutical products were discontinued (Naidoo & Suleman, 2021: 445). Additionally, between 2002 and 2017, 37 plants closed down, which reduced local production and led to growing reliance on imports (PMG, 2017).

Third, the specialisation in the industry observed from 2013, 2014, and 2016 could be attributed to the injection of ZAR10,2 billion (approximately USD 1.06 billion) into the pharmaceutical sector. A tender of ZAR10,2 billion was awarded in 2013 for the local production of ARVs. The tender was split into four suppliers; three were locally formulating the product, and one was a global monopoly in producing a particular type of ARVs (PMG, 2017).

Fourth, the outward specialisation seen from 2017 to 2018 may be attributed to a sharp decline in South Africa's global competitiveness from 47 in 2016 to 67 of 140 countries in 2018 (World Economic Forum, 2018). The global competitiveness report shows South Africa's weaknesses in terms of competitive performance emanate from the health pillar, which ranks 125th; ICT adoption, which ranks 85th; and the skills pillar, which ranks 84th. These are all areas that are key in pharmaceutical production. Policy inertia and deterioration in the government and private sector relationship appear to be the major causes of reduced South Africa's global competitiveness index (World Economic Forum, 2018).

Lastly, stringent global lockdowns to prevent the spread of COVID-19 could significantly explain the trade decline in 2020, which lead to specialisation out of the industry. According to the global competitiveness fact sheet, imports and exports for 2020 declined by 25% and 9%, respectively, compared to 2019. Exports declined by 60% between March and April 2020 (DHET, 2023). The results found in this study have important implications for the South African pharmaceutical industry in terms of adjustment costs and the movement of factors of production, which will be discussed in the summary and conclusions section below.

5.4.2 Analysis of Total Factor Productivity Results

The MTFP results in Table 8 below show the decomposition of Total Factor Productivity change (tfpch) into components like technical change (techch), efficiency change (effch), scale efficiency change (sech), and pure (allocative) efficiency change (pech). From 2002 to 2021, Total Factor Productivity was only driven by technical change, as other components showed no changes in the output mix (output mix =1). The results show significant technological changes in 2003, 2005, 2010, 2012, 2013, 2016, and 2021 because the index is greater than 1.

Table 8: The DEA results of TFP changes in the South African Pharmaceutical Sector

year	effch	techch	pech	sech	tfpch
2003	1.000	10.331	1.000	1.000	10.331
2004	1.000	0.336	1.000	1.000	0.336
2005	1.000	1.238	1.000	1.000	1.238
2006	1.000	0.988	1.000	1.000	0.988
2007	1.000	0.616	1.000	1.000	0.616
2008	1.000	0.424	1.000	1.000	0.424
2009	1.000	0.468	1.000	1.000	0.468
2010	1.000	18.931	1.000	1.000	18.931
2011	1.000	0.098	1.000	1.000	0.098
2012	1.000	3.241	1.000	1.000	3.241
2013	1.000	1.208	1.000	1.000	1.208
2014	1.000	0.699	1.000	1.000	0.699
2015	1.000	0.673	1.000	1.000	0.673
2016	1.000	4.711	1.000	1.000	4.711
2017	1.000	0.708	1.000	1.000	0.708
2018	1.000	1.016	1.000	1.000	1.016
2019	1.000	0.593	1.000	1.000	0.593
2020	1.000	0.233	1.000	1.000	0.233
2021	1.000	23.267	1.000	1.000	23.267

**Note: Explanation of acronyms: total factor productivity change (tfpch), technical change (techch), efficiency change (effch), scale efficiency change (sech), efficiency change (pech).*

Table 8 provides the results of TFP changes in the South African pharmaceutical sector using the DEA. The results show that variations in TFP are only driven by changes in technological progress, as efficiency-related metrics (effch, pech, sech) remain constant at 1.000 throughout the period. This suggests that productivity shifts result from advancements or regressions in technology rather than changes in operational or managerial efficiency. Regarding the

prodution possibilities curve, the technological changes led to an outward shift in the production possibilities frontier, denoting increased productivity.

These results resonate with past empirical studies like Ane (2020), Lakhwani *et al*. (2020), and Fagerberg (2018), who found that adoption of technological changes positively impacts productivity in organisations. However, in this case, these outward shifts fluctuate over time, implying inconsistency in technological improvement. This indicates the need for an active and aggressive development policy to support and sustain higher productivity levels in the pharmaceutical sector. The 1996 White Paper on Science and Technology emphasises that the government is primarily responsible for establishing a conducive policy environment regarding regulatory and funding mechanisms. Furthermore, the National System of Innovation (NSI) provides a solid foundation for organising the country's collective efforts in science and technology in a much more integrated and holistic fashion (Manzini, 2012).

To make the results more meaningful, the study examines the health sector to extract the factors that potentially improved technical changes, which led to the outward shift in the production possibilities curve during the study period. One significant factor was the massive-scale rollout of the Antiretroviral Therapy (ART) program in 2003, which catalysed technological advancements in the healthcare sector. Like most developing countries, the National Department of Health in South Africa adopted technology applications to enhance health information management, as reflected in the National Health Act (Act 61 of 2003). For example, the expansion of the ART program likely spurred increased adoption of electronic health records (EHRs), enabling healthcare providers to digitally capture and manage patient information, including HIV/AIDS-related data. Furthermore, technologies like medication management, telemedicine, and telepharmacy services were all implemented around this period to cater to the increased demand for ART treatment (PC4IR, 2020). Other advanced instruments and technologies that pharmaceutical manufacturers adopted were to help ensure the quality and safety of their products and maintain quality control and compliance.

From 2010 to 2016, the notable technological changes that gained traction in the South African pharmaceutical space were primarily driven by the integration of automation into production as manufacturers embraced the Fourth Industrial Revolution (4IR) in manufacturing (PC4IR 2020). Manufacturers integrated automation across various stages of production like formulation, filling, and packaging. This period witnessed the adoption of advanced manufacturing techniques, such as continuous manufacturing, leading to a drastic improvement

in the volume of products produced daily (PC4IR, 2020). There was also a growing interest in the production of Biopharmaceuticals during this period, which required Biotechnology. For instance, in October 2016, Cipla BioTech and Dube Tradeport signed a memorandum of agreement to establish a facility for producing the first biosimilar drug, which was later launched in 2018. Cipla invested about $88m in the facility through its biotechnology subsidiary, Cipla BioTech (Cipla SA, 2022).

Finally, in 2021, rapid technological improvements were needed to develop the pharmaceutical supply chain resilience because of Covid-19. In the wake of the pandemic, various sectors swiftly joined forces to mitigate the repercussions of the crisis. UNIDO (2021) reported that South African universities, in particular, collaborated closely with national and local governments and industry partners to manufacture essential personal protective equipment (PPE) and ventilators. For instance, the University of Johannesburg's engineering team designed and created portable 3D-printed mechanical ventilators featuring adaptable base plates to cater to many patients simultaneously.

On the contrary, the technical regressions observed in 2008 and 2009 that resulted in an inward shift of the production possibilities curve could be attributed to the global financial crisis, while the regression in 2020 could result from the countries' lockdown to prevent the spread of COVID-19. While the technological improvements discussed in this section are not the only factors that influenced changes in technological efficiencies in the pharmaceutical industry, they were identified as remarkable milestones achieved in the industry during the study period.

Interestingly, it is noted that instances of industry specialisation (2002, 2013, 2014, and 2016) and significant intra-industry changes (2008, 2010, and 2011) fall within the period during which the industry experienced technological advancements. While the pattern may suggest a positive relationship between favourable trade activities and technology improvement, correlation does not imply causation. Understanding causation relationships requires further research.

5.5 Summary and Conclusion

The MIIT and UMCIT results showed that new trade is inter-industry, and specialisation is often out of the industry. This finding confirmed the popular view in the literature that intra-industry trade is more prevalent in developed than developing countries. However, while trade

was found to be largely inter-industry, there was evidence of significant intra-industry changes in 2008, 2010, and 2011 and periods of industry specialisation in 2002, 2013, 2014, 2016, and 2019. The DEA results showed that technological changes strongly influence the Total Factor Productivity. The results further revealed that the big technical changes coincided with industry specialisation and significant intra-industry trade. Therefore, investing in new technology is necessary to help the industry withstand the harsh global competition and drive efficiency and productivity improvement in the South African pharmaceutical industry.

Chapter 6
Estimating Comparative Advantage in the South African Pharmaceutical Sector

6.1 Introduction

As countries become more open to trade, they encourage increased competition and establish new avenues for exchanging knowledge and transferring technology. For developing countries, trade offers the opportunity to transform raw materials into value-added goods while acquiring technological know-how from more advanced countries. This global integration leads to dynamic gains such as increased productivity and restructuring of an economy in alignment with its comparative advantage. The dynamic gains emanate from better allocation of resources, increased income, savings, investment, and standard of living (Schumacher, 2013; Batra & Khan, 2005; Findlay, 1991). Increased productivity and dynamic comparative advantage gains are an essential combination for encouraging trade specialization and sustainable growth in the South African pharmaceutical industry, as it is a significant exporter to the Southern African Development Community (SADC) countries. This makes South Africa strategically important in initiatives to develop pharmaceutical manufacturing in Africa because of its well-established infrastructure, industrial base, and robust regulatory framework provided by the South African Health Products Regulatory Authority (SAHPRA). The country's market access, domestically and regionally, provides opportunities for scaling up production and addressing healthcare needs in neighboring countries. South Africa's strong research and development capabilities combined with global partnerships are necessary to facilitate innovation and technology transfer in the pharmaceutical sector. Government support and policies further highlight South Africa's potential to play a critical role in advancing pharmaceutical manufacturing across the continent, contributing to enhanced healthcare access and economic development.

Most African countries have low to non-existent pharmaceutical manufacturing capacity except South Africa, Tunisia, Egypt, Algeria, Nigeria, Kenya, and Morocco. As such, studies of comparative advantage focusing on the African pharmaceutical industry are scarce. Studies that have examined the South African pharmaceutical sector have not made a deep inquiry into the trade aspect except pointing out that it is import-dependent (Veitch, 2020; Rayment, 2020; Viviers *et al*., 2014; Te Naudé & Luiz, 2013; and Maloney & Segal, 2007). This chapter provides a detailed analysis of trade and comparative advantage in the South African pharmaceutical sector, aiming to capture its pattern over the past two decades. This analysis is important for four reasons.

First, as countries develop more refined comparative advantages in quality, branding, or innovation, intra-industry trade becomes a dominant trade mode (Fontagné *et al*., 2006). Second, determining a comparative advantage in the pharmaceutical can lead to more resources allocated to the products that are more efficiently produced, as the theory of comparative advantage suggests. Third, the method used to analyse data allows for comparing the comparative advantages across the product categories and countries, which reveals the production complementarity between South Africa and the selected trading partners from Africa, emerging, and developed countries. Fourth, this analysis feeds into the agenda of the African Continental Free Trade Agreement (AfCFTA), which aims to enhance intra-African trade in medicines and pharmaceuticals; as such, the pharmaceutical industry is likely to be among the prime beneficiaries of the introduction of frictionless trade in Africa (World Economic Forum, 2023). The World Economic Forum (2023) also believes that the AfCFTA has the potential to spur collaborations among governments, businesses, and international organizations to promote a transition from dependence on donor funding to the establishment of robust, sustainable healthcare systems throughout the Sub-Saharan Africa region.

Furthermore, the chapter subsequently measures trade complementarity to identify trade alignment among the trading partners. Most trade complementarity studies focus on the complementarity in different sectors. This chapter conducts an 'intra-industry trade complementarity' inquiry, which is often neglected due to the generally low intra-industry trade in Africa. The trade complementarity index reveals more export opportunities for South Africa and its trading partners. Identifying trade complementarity is necessary for African countries to intensify the limited intra-African trade, which currently stands at 14% of Africa's total trade (ITC Trade Map, 2022).

Additionally, since the dawn of democracy in 1994, South Africa has strengthened its trade relationships with other emerging countries and has participated in skills and knowledge-sharing initiatives (e.g., BRICS[11] and IBSA[12]). Among these partner countries, India emerges as a country with deep pharmaceutical trade connections with South Africa while maintaining a significant presence in the global pharmaceutical space as a champion of generic manufacturing. The partnership with India has paved the way for collaborative research in

[11] Brazil, Russia, India, China, South Africa are the initial members of the group, joined by Saudi Arabia, Iran, Ethiopia, Egypt and the United Arab Emirates at the beginning of 2024.

[12] India-Brazil-South Africa

biotechnology and medical sciences as both countries continue to navigate the challenges and opportunities presented by the evolving global environment. These trade connections may have reshaped comparative advantage in global pharmaceutical manufacturing, which further necessitates the study of this nature.

Many comparative advantage studies analyse the countries' specializations in commodities from diverse industries. This chapter investigates the pharmaceutical sector and analyse the countries' specialization across commodity groups according to their product codes (Appendix B, Table 2). This is because the pharmaceutical industry produces diverse products, meaning that a country can produce some of the pharmaceutical products more efficiently than other countries while having a disadvantage in producing other products than other countries within the same industry. Therefore, the theory of comparative advantage provides a useful lens through which to examine the comparative advantage in the South African pharmaceutical sector. The rest of the chapter is structured as follows: Section 6. 2 discusses the chapter's theoretical framework. Section 6.3 deals with data sources and the methodology used in this chapter. Section 6. 4 presents the results, while Section 6. 5 discusses the results.

6.2 Theoretical Framework

The genesis of comparative advantage studies can be traced back to the pioneering work of Ricardo (1821) in his classical theory of comparative advantage. Thus, the point of departure for this section is the conventional notion of comparative advantage, which argues that a country does not need to have an absolute advantage in producing a product to benefit from trade. The basis for trade exists as long as the domestic opportunity cost of producing the product is lower than that of a trading partner. The emphasis is on comparative or relative advantage rather than absolute advantage (Gupta, 2014). However, Ricardo (1821) did not go further to explain the source of differing comparative advantages. Heckscher and Ohlin (1919) addressed this limitation by asserting that the comparative difference between two trading partners emanates from differing factor endowments. The explanations of differing comparative advantage have evolved since Heckscher and Ohlin (1919).

One explanation is in the work of Schultz (1961) and Becker (1975), who coined a theory that emphasises human capital as the key factor underlying comparative advantage. The central argument in this theory is that the skills and abilities of individuals play a crucial role in determining the comparative advantage of a country or an entity in international trade and economic activities. Vernon (1966, 1979) developed the Product Life Cycle model, which

attributes the origin of comparative advantage in producing new goods to factors that may evolve throughout the product's life. This model asserts that comparative advantage in producing new goods can change throughout a product's life due to evolving factors relating to the production of the product.

On another note, Davis (1995) pointed out that technical differences become significant in trade when the expansion of a specific sector does not cause the marginal opportunity cost to increase. This assertion implies that the efficiency and cost-effectiveness of different sectors in trade become significant when expanding one sector, which does not lead to higher opportunity costs. On a different note, Nunn & Trefler (2014) identify contracting institutions as a source of comparative advantage. They challenge classical Ricardo and Heckscher-Ohlin views of comparative advantage that emphasize technology and innovation, together with physical and human capital, as primary drivers of economic growth. They claim these factors are outcomes of more profound social, political, and economic dynamics collectively labeled as 'institutions.' Regardless of its origin, comparative advantage provides the rationale for inter-industry and, in modern trade dynamics, even intra-industry trade, reflecting how countries maximise their unique strengths, whether natural, developed, or policy-driven, to participate effectively in global markets (Sinanan & Hosein, 2012).

6.3 Empirical literature review

The theory of comparative advantage has led to numerous empirical studies aimed at measuring comparative advantage in various sectors. This section examines some works that specifically focused on measuring comparative advantage and competitiveness in the pharmaceutical industry to situate the contribution of this chapter to existing literature. The glaring feature of most studies in the pharmaceutical trade is that they are based on industrialized economies and a few emerging countries that are recognized as notable players in the field. As such, Nte *et al*. (2020) is the only study found to be conducted within the pharmaceutical industry in Africa, focusing more on competitive advantage rather than comparative advantage in the Nigerian pharmaceutical sector. This further highlights the limited availability of literature in this particular domain. However, over the years, some developing African countries have developed considerable pharmaceutical manufacturing capabilities and are involved in trade, but have received little attention in the literature. Therefore, much of the literature discussed in this section is based on industrialized economies, a few emerging countries, and one from Africa.

A study by Yusefzadeh *et al*. (2015) investigated comparative advantages in Iran's pharmaceutical industry to identify its unique strengths. They used the Balassa and Vollrath indexes to measure trade specialization, export propensity, and import penetration. These indexes were compared to other countries engaged in pharmaceutical exports. This study also assessed the scope and expansion of Iran's intra-industry trade in the pharmaceutical field using the Grubel-Lloyd and Menon-Dixon indexes to analyze data sourced from Iran's Customs Administration, Iran's pharmaceutical statistics, the World Bank, and the International Trade Centre. Their results showed Iran's significant comparative disadvantage in the pharmaceutical product category due to its relatively small share in the global pharmaceutical export market. Furthermore, the limited extent of bilateral intra-industry trade involving pharmaceuticals between Iran and its trade partners[13] indicates that Iran's trade in pharmaceutical products is predominantly inter-industry trade rather than intra-industry trade.

Using the Revealed Comparative Advantage Index (RCAI) and Trade Specialization Coefficient (TSC), Mahajan *et al*. (2015) conducted a study to examine trade performance, revealed comparative advantage and trade specialization indices of Indian pharmaceuticals following the amendments to the Indian Patent Act. The results showed that India ranks 3rd globally concerning Total Competitive Score, with a notable gap between Ireland ranking 1st and Israel ranking 2nd. Ireland has made rapid advancements in the value chain since 1995, while Israel experienced a swift ascent since 2000, leveraging global production networks and supply chains. In contrast, the Indian pharmaceutical industry has primarily leveraged its cost-effective production of generic drugs and a substantial domestic market. The RCAI results corroborate the TCS findings, placing India at the 11th spot, with a significant distance from the leading position held by Ireland, followed by Israel, Switzerland, Belgium, and the UK.

Mousavi *et al*. (2018) conducted a study with the primary objective of examining and assessing the global competitiveness of the pharmaceutical industry in selected developed nations[14] from 2000–2012. Their study employed conventional, innovative competitiveness metrics and the static and dynamic intra-industry trade (IIT) indices. The results revealed an increasing level of competitiveness in the majority of the countries under consideration. Moreover, the findings strongly implied that nations engaged in more extensive international trade of pharmaceutical

[13] Afghanistan, Armenia, Azerbaijan, Belgium, China, France, Germany, India, Iraq, Jordan, Pakistan, Somalia, Sudan, Switzerland, Tajikistan, Ukraine, United Kingdom and Yemen.
[14] European Union-27, USA, Switzerland, France, Ireland, Portugal, China, Hong Kong SAR, Slovenia, Norway, Luxembourg.

products possess a greater potential for competitiveness, as indicated by the Intra-Industry Trade and comparative advantage indices.

Salikhova (2020) examined the rise of new players in the global pharmaceutical market, driven by transnational corporations (TNCs) and technology transfers in developing countries. The study explored factors motivating TNCs to relocate production and highlighted the resulting implications using the cases of Puerto Rico and Ireland for illustration. This study also introduced the comparative advantage in value-added activity (CAVA) ratio to evaluate comparative advantages in high-tech pharmaceutical manufacturing. The research found that countries that were once importers have become key suppliers due to internationalization, primarily led by American and European multinational corporations. The study emphasized the need for re-evaluating traditional approaches to assessing comparative advantages in global trade when new market players emerge from developing nations. The study highlighted that the classical Revealed Comparative Advantage (RCA) index might not adequately measure these shifts.

A study by Nte *et al*. (2020) investigated the impact of competitive intelligence on the competitive advantage of pharmaceutical companies in Lagos State, Nigeria. The study employed a survey research design and collected data through structured questionnaires, which were analyzed using the one-sample t-test statistic. The results indicated a significant relationship between competitive intelligence and competitive advantage, showing that competitive intelligence provides crucial strategic information for enhancing marketing innovations and meeting customer needs. One of the recommendations from the study was that pharmaceutical companies could enhance their competitive edge and improve performance by using valuable information from their environment, not just by focusing on product development, but also by consistently innovating and adjusting their current marketing strategies.

The literature reviewed shows that only Yusefzadeh *et al*. (2015) focused on measuring the pharmaceutical sector's comparative advantage and export performance. The study by Salikhova (2020) mainly focused on shedding light on the decision-making processes of TNCs and providing a new tool for analyzing comparative advantages in the pharmaceutical industry. Studies by Mousavi *et al*. (2018) and Mahajan *et al*. (2015) placed more emphasis on competitive rather than comparative advantage despite including the measurement of comparative advantage in the objectives of their studies.

While competitive advantage is important for individual firms, this study concurs with Gupta (2014), Neary (2003), and Warr (1994) in arguing that comparative advantage plays a critical role in shaping a country's international trade performance and remains a key determinant of international production and trade patterns. No study was found that provides a detailed analysis of trade and comparative advantage in the South African pharmaceutical sector, other than those[15] that indicated that the country is a major importer. This study also captures the trends in the exports and imports of pharmaceuticals over the period that covers before and after the global recession and pre - and post-COVID-19 periods, which none of the studies cover.

Like Yusefzadeh *et al*. (2015), this study will use the Balassa index (BI) to measure comparative advantage. However, this analysis employs an improved version of the Balassa index, known as the Normalised Revealed Comparative Advantage (NRCA). This index enables the study to make more accurate comparisons over time between countries and commodities and to properly attest to indications of the underlying comparative advantage. Additionally, this study covers a more extended period than the six years in Yusefzadeh *et al*. (2015).

6.4 Methodology

6.4.1 Research Paradigm and Data Description

The research design of this study follows a positivist approach, a paradigm that requires gathering data and specifying models to examine a phenomenon through the lens of empirical evidence and systematic analysis (Creswell & Creswell, 2017). This involves developing models representing the underlying structures and patterns of the situation under investigation using data. The study used trade data for pharmaceutical products disaggregated at the HS 4-digit level for 2001-2022 from the Trade map to calculate the Normalised Revealed Comparative Advantage. The HS 4-digit level was the most disaggregated data available for pharmaceutical products. However, only data for 2022 and 2023 were used to calculate the Trade Complimentarity Index because they are recent and relevant given the impact of the COVID-19 pandemic on global trade patterns, supply chains, and medical product demand. This period captures the post-pandemic dynamics in the pharmaceutical sector, which provides

[15] Veitch (2020); Rayment (2020); Viviers *et al*. (2014); Te Naudé and Luiz (2013); and Maloney and Segal (2007).

a realistic measure of complementarity that reflects the current import and export profiles of trading partners. The HS codes in the pharmaceutical sector are explained in Table 9 as follows:

Table 9. Explanation of the pharmaceutical product codes

Product code	Product description
HS 3001	*Dried glands and other organs for organo-therapeutic uses, whether or not powdered; extracts of glands or other organs or their secretions, for organo-therapeutic uses; heparin and its salts; other human or animal substances prepared for therapeutic or prophylactic use.*
HS 3002	*Human blood; animal blood prepared for therapeutic, prophylactic or diagnostic uses; antisera and other blood fractions and immunological products, or not modified or obtained by means of biotechnological processes; vaccines, toxins, cultures of micro-organisms (excluding yeasts) and similar products.*
HS 3003	*Medicaments consisting of two or more constituents mixed together for therapeutic or prophylactic uses, not in measured doses or put up for retail sale (excluding goods of heading 3002,3005 or 3006).*
HS 3004	*Medicaments consisting of mixed or unmixed products for therapeutic or prophylactic uses, put up in measured dose "incl. those in the form of transdermal administration" or in forms or packings for retail sale (excluding goods of heading 3002,3005 or 3006).*
HS 3005	*Wadding, gauze, bandages, and the like, e.g. dressings, adhesive plasters, poultices, impregnated or covered with pharmaceutical substances or put up for retail sale for medical, surgical, dental, or veterinary purposes*
HS 3006	*Pharmaceutical preparations and products of subheadings 3006.10.10 to 3006.60.90*

Source: UNComtrade (2022)

As alluded to in the introduction, the examination process involves South African trade in the pharmaceutical sector with selected trading partners. The selected countries are comprised of African, developed, and emerging countries. As such, Algeria, Egypt, Kenya, Morocco, Nigeria and Tunisia are the few African countries that are included in this study because they have considerable pharmaceutical manufacturing as compared to other countries in the continent. Brazil, China, and India were selected to represent non-African emerging countries (which are referred to as 'emerging countries' throughout the document) that have close trade relations with South Africa. Furthermore, China and India are countries from which a significant portion of South Africa's pharmaceutical imports originate. Lastly, Belgium, France, Germany, Italy,

Netherlands, Switzerland, the United Kingdom (UK), and the United States of America (USA) are examined as they represent some of the developed countries globally dominant in pharmaceutical trade and trade in pharmaceuticals with South Africa.

6.4.2 The Revealed Comparative Advantage Index

The Revealed Comparative Advantage (RCA) index developed by Balassa (1965) is widely used in empirical studies to determine the country's weak and strong sectors and to compare comparative advantages over time (Hinloopen & Van Marrewijk, 2001; Hiley, 1999; Dalum *et al*., 1998). The introduction of the BRCA index was to offset the unavailability of countries' autarky prices, an important feature of the comparative advantage theory. Balassa's index (BI), which is sometimes referred to as the Balassa Revealed Comparative Advantage (BRCA), is expressed as:

$$BRCA_{ij} = (E_{ij} / E_{in}) \div (E_{wj} / E_{wn}) \quad (1)$$

Where E_{ij} represents country *i's* exports of commodity *j*; E_{in} is country *i's* exports of all *n* commodities; E_{wj} is the exports of the world for commodity *j* and E_{wn} is the world's export of all *n* commodities (Ahmad *et al*., 2017). Country *i*'s comparative advantage in commodity *j* is indicated by $BRCA_{ij} > 1$. On the contrary, country *i*'s comparative disadvantage in commodity *j* is indicated by $BRCA_{ij} < 1$. A "neutral" comparative advantage in commodity *j* is indicated by $BRCA_{ij} = 1$ (Yu *et al*., 2009).

Despite the widespread adoption of the Balassa index, it has faced heavy criticism. First, Vollrath (1991) and Bowen (1983) criticised the $BRCA_{ij}$ for not precisely adhering to the fundamental principles of Ricardian comparative advantage in its theoretical underpinnings. Second, Hinloopen and Van Marrewijk (2001) pointed out that the $BRCA_{ij}$ index exhibits suboptimal empirical distribution characteristics due to its skewed distribution, with a median significantly below one and a mean notably above one. Third, Yu *et al*. (2009) and Yeast (1985) criticised the index for being inherently asymmetric because it has a fixed lower bound of 0 with 1 serving as a neutral point, while the upper bound remains undefined, rendering it unreliable in measuring comparative advantage consistently. Consequently, the $BRCA_{ij}$ index may yield varying indications of comparative advantage for different countries or commodities, raising doubts about its cross-country or cross-commodity comparability. This means the $BRCA_{ij}$ index could give misleading results because countries with a small export market share seem to have a strong comparative advantage (Yeast, 1985). A series of new $BRCA_{ij}$ constructs

emerged to address the shortcomings of the Balassa Index. Liu and Gao (2019), summarised the Balassa Index and its alternatives constructs in Appendix F Table 9.

Having observed that none of the alternative measures of *BRCA* managed to address all of its shortcomings, Yu *et al*. (2009) derived the Normalised Revealed Comparative Advantage (NRCA) to allow more accurate comparisons over different periods, countries, and industries. The comparative-advantage-neutral point is key to deriving the *NRCA* index, consistent with all existing *RCA* measures. The condition of the comparative-advantage-neutral point follows that country *i*'s exports of commodity *j, ($\hat{E}_{ij}$)* would be equal to $E_i\ E_j/E$. However, in the real world, country *i*'s actual exports (E_{ji}) would differ from $\hat{E}_{ij}$ and the difference can be shown in equation (2) below.

$$\Delta E_{ij} \equiv E_{ij} - \hat{E}_{ij} = E_{ij} - (E_i\ E_j)/E \quad (2)$$

Where ΔE_{ij} represents difference in normalized comparative advantage between two periods or regions and $\hat{E}_{ij}$ represents the exports of commodity *j* by country *i*.

Normalizing ΔE_{ji} by the world export market, E, the NRCA index is derived as follows:

$$NRCA_{ij} \equiv \Delta E_{ij}/E = E_{ij}/E - E_i\ E_j/EE \quad (3)$$

E_j is the exports of commodity *j* by the world, E_i is the total exports of country *i* and *E* represents the world's total exports. The $NRCA_{ij}$ index measures how much a country's actual export deviate from its comparative-advantage-neutral point relative to its scale within the global export market. If country *i*'s actual export of commodity *j* (E_{ji}) is higher (or lower) than its comparative-advantage-neutral point ($NRCA_{ij} = 0$), ($\hat{E}_{ij}$) given by $NRCA_{ij} > 0$ (or $NRCA_{ij} < 0$), it indicates that country *i* has a comparative advantage (or disadvantage) in commodity *j*. The strength of the comparative advantage (or disadvantage) depends on the size of the $NRCA_{ij}$ score. For example, if country *i* exports two commodities, say commodity *k* and commodity *j* and $NRCA_{ij} = 0.01$ while $NRCA_{ik} = 0.05$, it means that the relative strength of country *i*'s comparative advantage in commodity *k* is five times of its comparative advantage in commodity *j*.

The $NRCA_{ij}$ index possesses useful properties that are important from a theoretical perspective and for empirical research. Yu *et al*. (2009: 272) explain the properties as follows:

First, the $NRCA_{ij}$ index is additive regarding both countries and commodities. This additive property means that the measurement of comparative advantage using the $NRCA_{ij}$ index remains unaffected by how commodities and countries are categorised. Consequently, the levels at

which data is aggregated do not impact the measurement of comparative advantage, making it valuable for empirical studies.

Second, the possible distribution of $NRCA_{ij}$ scores is symmetrical, ranging from -1/4 to +1/4 with 0 being the comparative-advantage-neutral point (Bojnec & Ferto 2018). The higher the positive value, the stronger the advantage, and the higher the negative value, the stronger the disadvantage (Ahmad *et al*., 2017: 69). It is evident from literature discussions on alternative $BRCA_{ij}$ indices that the asymmetry property is deemed most desirable.

Third, unlike the $BRCA_{ij}$, $SRCA_{ij}$ and $WRCA_{ij}$ indices where they assign the constant value of 0 for zero export, the *NRCAij* score for zero export is not invariant. As such, the $NRCA_{ij}$ index could capture the situation of zero export in a more reasonable manner. The export market size for each commodity and country under the hypothetical comparative-advantage-neutral situation would be the same as that of the actual export market in reality. It implies that:

$$\sum_i \Delta E_{ij} \equiv \sum_i \left(\hat{E}_{ij} - E_{ij}\right) = 0 \tag{4}$$

and

$$\sum_j \Delta E_{ij} \equiv \sum_j (\hat{E}_{ij} - E_{ij}) = 0 \tag{5}$$

First, the total (and average) of an individual country or a commodity's $NRCA_{ij}$ values remains constant adding up to zero. Consequently, the sum of positive $NRCA_{ij}$ matches the summation of negative $NRCA_{ij}$ for each specific commodity or country. This implies that if a country gains a comparative advantage in a commodity, other countries have to lose a comparative advantage in some commodities. Similarly, if a country gains comparative advantage in some commodities, it must lose comparative advantage in some other commodities. This characteristic aptly mirrors the notion of comparability across-commodity and country, reflecting the essence of comparative advantage.

For cross-commodity comparison within a country, the difference between $NRCA_{ij}$ scores of commodity1 and 2 is given by:

$$\Delta\, NRCA^i_{1-2} \equiv NRCA^i_1 - NRCA^i_2 = \frac{E^i}{E}\left[\left(\frac{E^i_1}{E^i} - \frac{E_1}{E}\right) - \left(\frac{E^i_2}{E^i} - \frac{E_2}{E}\right)\right] \tag{6}$$

Equation (6) shows that cross-commodity comparison of NRCA scores essentially compares the relative specialization level that a country has in these two commodities. $\Delta NRCA^i_{1-2} > 0$

(or $\Delta NRCA^{i}_{1-2} < 0$) indicates that country *i*'s relative specialization level in commodity 1 with respect to the world's average specialization level in commodity1 (measured by $\frac{E^{i}_{1}}{E^{i}} - \frac{E_1}{E}$) is stronger (or weaker) than its relative specialization level in commodity 2 (measured by $\frac{E^{i}_{2}}{E^{i}} - \frac{E_2}{E}$) and therefore country *i* has stronger (or weaker) comparative advantage in commodity 1 than in commodity 2. The cross-commodity feature helps to identify the commodity group that is produced more efficiently than others in a specific country and, therefore, reflects the strongest comparative advantage. This feature is also useful to identify complementarity between trading partners by revealing each country's strongest and weakest comparative advantage in producing the goods in question.

For cross-country comparison concerning an individual commodity, the difference between the $NRCA_{ij}$ scores of countries 1 and 2 is given by:

$$\Delta NRCA^{1-2}_{j} \equiv NRCA^{1}_{j} - NRCA^{2}_{j} = \frac{E_j}{E}\left[\left(\frac{E^{1}_{j}}{E_j} - \frac{E_1}{E}\right) - \left(\frac{E^{2}_{j}}{E_j} - \frac{E_2}{E}\right)\right] \quad (7)$$

Equation (7) shows that a cross-country comparison of NRCA scores measures the relative performance of the two countries in a commodity. $\Delta NRCA^{1-2}_{j} > 0$ (or $\Delta NRCA^{1-2}_{j} < 0$) indicates that country 1's relative export performance in commodity *j* with respect to its average export performance (measured by $\frac{E^{1}_{j}}{E_j} - \frac{E^{1}}{E}$) is stronger (or weaker) than country 2's relative export performance in commodity *j* (measured by $\frac{E^{2}_{j}}{E_j} - \frac{E^{2}}{E}$) and therefore country 1 has stronger (or weaker) comparative advantage than country 2 in commodity *j*. This feature is useful in providing a detailed analysis of how efficiently countries are in producing specific products as compared individual trading partners.

Furthermore, the $NRCA_{ij}$ has a temporal comparison feature that allows one to conduct time-series analysis which examines the dynamics of comparative advantage (Yu *et al*. 2009). The time comparison property is useful in studying countries' comparative advantage considering that the introduction of the $BRCA_{ij}$ index was to offset the unavailability of countries' autarky prices, an important feature of the comparative advantage theory. The $NRCA_{ij}$'s properties concerning the sum, the mean value, and the distribution are time-invariant, which establishes the comparability of $NRCA_{ij}$ over time. The variation of $NRCA_{ij}$ scores between time t +1 and t is given by:

$$\Delta NRCA^{i}_{j,t+1} \equiv NRCA^{i}_{j,t+1} - NRCA^{i}_{j,t} = \left(\frac{E_{j,t+1}}{E_{t+1}} - \frac{E^{i}_{j,t}}{E_t}\right) - \left(\frac{E^{i}_{t}}{E_t}\frac{E_{j,t}}{E_t} - \frac{E^{i}_{t+1}}{E_{t+1}}\frac{E_{j,t+1}}{E_{t+1}}\right) \quad (8)$$

Where $\left(\frac{E_{j,t+1}}{E_{t+1}} - \frac{E^i_{j,t}}{E_t}\right)$ measures the change of country *i*'s actual export level of commodity *j* between time *t* + 1 and *t*. As $\frac{E^i_t}{E_t}\frac{E_{j,t}}{E_t}$ and $\frac{E^i_{t+1}}{E_{t+1}}\frac{E_{j,t+1}}{E_{t+1}}$, respectively, are country *i*'s expected export level of commodity *j* under the comparative-advantage-neutral situation at time *t* and t + 1, $\left(\frac{E^i_t}{E_t}\frac{E_{j,t}}{E_t} - \frac{E^i_{t+1}}{E_{t+1}}\frac{E_{j,t+1}}{E_{t+1}}\right)$ then measures the change in country *i*'s export volume in commodity *j* that is required to sustain its comparative-comparative-neutral status from time *t* to t + 1. Therefore, when examining comparative advantage over time, it essentially compares the actual change of a country's export level of an individual commodity to the expected change of this commodity's export level that the country would have under the comparative-advantage-neutral situation. $\Delta NRCA^i_{j,t+1} > 0$ or ($\Delta NRCA^i_{j,t+1} < 0$) indicates that the growth of country *i*'s actual export level of commodity *j* $\left(measured\ by\ \frac{E_{j,t+1}}{E_{t+1}} - \frac{E^i_{j,t}}{E_t}\right)$ is higher (or lower) than the expected growth that is necessary for country *i* to maintain the comparative-advantage-neutral level in this commodity $\left(measured\ by\ \frac{E^i_t}{E_t}\frac{E_{j,t}}{E_t} - \frac{E^i_{t+1}}{E_{t+1}}\frac{E_{j,t+1}}{E_{t+1}}\right)$. Consequently, $\Delta NRCA^i_{j,t+1} > 0$ (or $\Delta NRCA^i_{j,t+1} < 0$) signifies that country *i* has increased (or decreased) its comparative advantage in commodity *j* between time *t* + 1 and *t*. Therefore, this study will use the $NRCA_{ij}$ index to measure the comparative advantage in the South African pharmaceutical sector because it has fewer limitations compared to other indices and it provides a proper indication of the underlying comparative advantage (Yu *et al*., 2009).

It is worth acknowledging that while researchers depend on comparative advantage indices, like the $NRCA_{ij}$, to identify areas of comparative advantage, these indices are still criticized for not having a clear theoretical derivation due to constraints caused by the absence of autarky prices. Furthermore, applied national measures that affect competitiveness, like tariffs, Non-Tariff Barriers (NTBs), and subsidies, among others, are not considered by any $NRCA_{ij}$ indices. Therefore, the results should be interpreted with caution.

6.4.3 Trade Complementarity Index

The trade complementarity index measures how well one country's export profile matches another's import profile, which helps to assess the degree to which two countries have complementary trade structures. Michaely (1996) introduced the TCI to measure the extent to which two countries are "natural trading partners," indicating whether a country's exports are in goods that are in demand by its trading partner (i.e., imports of the partner country). The TCI

reflects the potential for trade cooperation or market alignment between two countries. A trade complementarity index between countries *i* and *j*, say on the import side (it can also be calculated on the export side), approximates the adequacy of *j* 's export supply to *i*'s import demand by calculating the extent to which *i*'s total imports match *j* 's total exports. With a perfect correlation between sectoral shares, the index is one hundred; with a perfect negative correlation, it is zero. Formally, let m_k^i be sector *k* 's share in *i*'s total imports from the world and x_k^j its share in *j* 's total exports to the world. The import TCI between *i* and *j* is then:

$$c^{ij} = 100\left[1 - \sum_{k=1}^{m} \left|m_k^i - x_k^j\right|/2\right] \quad (9)$$

Computing both comparative advantage and TCI provides more robust results because the comparative advantage results indicate a single country's relative strength in specific products compared to the world. At the same time, the TCI will evaluate the degree of trade alignment and the potential for beneficial trade relationships between them. The trade complementarity will only focus on South Africa and the selected emerging and African countries, as South Africa continues to strengthen trading ties with BRICS, considering the proposed trade intensity under the AfCFTA.

6.5 Presentation of results: Comparative Advantage results

This section starts by presenting the NRCA results to offer insights into the relative strengths and weaknesses of countries in the global trade of pharmaceuticals. In order to gain a deeper understanding of the competitive forces shaping pharmaceutical trade patterns in South Africa, this section proceeds to discuss possible factors that could have contributed to the results obtained. Thereafter, the section presents the trade complementarity results given by the TCI followed by a summary. As such, we start off by discussing NRCA results for African countries.

6.5.1 The NRCA results for African countries

The paucity of studies that examine the comparative advantage in the pharmaceutical sector for African countries has already been highlighted in the previous sections. Therefore, the results of this study will be compared to similar studies undertaken in any part of the world. For ease of reference, Table 11 was constructed to provide a summarised indication of which countries possess a comparative advantage, disadvantage, or are comparative advantage-neutral in producing pharmaceutical products. Table 11 is based on the results in Tables 12 to 18 (in Appendix G), showing the actual results of NRCA for the selected African countries. Starting

with African countries, Table 11 shows that out of the selected African countries, Egypt, Tunisia, Morocco, and Nigeria are the only countries that showed a comparative advantage in producing some pharmaceuticals.

Table 11: NRCA results for African countries

Product code	South Africa	Egypt	Nigeria	Algeria	Morocco	Tunisia	Kenya
HS3001	No	No	No	No	No	Yes	No
HS3002	No	Yes	No	No	Yes	No	No
HS3003	No	Yes	Yes	No	Yes	No	No
HS3004	Dis	Yes	No	No	Yes	No	No
HS3005	No	Yes	No	No	Yes	Yes	No
HS3006	No	No	No	No	Yes	Yes	No

Source: own table derived from Tables 12-18 in Appendices G.
*Note: Yes = comparative advantage, No = comparative advantage neutral and Dis = Comparative Disadvantage.

Table 11 shows that South Africa has a comparative disadvantage in category HS3004 and is consistently comparative advantage-neutral in five product categories. Egypt has a comparative advantage in five categories and is comparative-advantage neutral in HS3006. Notably, the comparative advantage in category HS3004 shows a significant improvement of an average of 51% between 2006 and 2010 and remains high until 2020 (Table 13, Appendix G). Nigeria has a comparative advantage in HS3003 and is comparative-advantage neutral in the other five categories. Morocco has a comparative advantage in 5 categories and is comparative-advantage neutral in HS3001. Table 11 also shows that Algeria has a comparative advantage neutral in all categories. However, there were occasional years of comparative advantage in 2007, 2009, 2015, 2016, and 2017 (Table 16, Appendix G). Tunisia has a comparative advantage in categories HS3006, HS3005, and HS3001 and is comparative-advantage neutral in all other categories. Lastly, Kenya is comparative advantage-neutral in all product categories. As expected, most African countries have either low or no comparative advantage. The similar results for South Africa, Kenya, and Algeria imply that there are common underlying challenges that lead to these countries struggling to achieve a comparative advantage in pharmaceutical products. These may be structural and policy challenges that limit manufacturing capacity and R&D investment (Kaplan & Laing, 2005). Furthermore, the limited export markets and a shortage of skilled professionals potentially contribute to a lack of comparative advantage (AUDA-NEPAD, 2012). Despite these challenges, there is potential to improve comparative

advantage in most product categories if these countries could implement appropriate strategies to improve their efficiency and pharmaceutical exports.

Similarly, Table 19 below provides a summarised report of emerging countries' comparative advantage in producing pharmaceutical products. The table is based on Tables 20-22 in Appendix H. Surprisingly, all selected emerging countries showed no comparative advantage except India, which showed a comparative advantage in producing HS3004.

Table 19: NRCA results for emerging countries

Product code	China	India	Brazil
HS3001	No	No	No
HS3002	Dis	Dis	No
HS3003	No	No	No
HS3004	Dis	Yes	Dis
HS3005	No	No	No
HS3006	No	No	No

Source: own table derived from Tables 20-22 in Appendices H.
*Note: Yes = comparative advantage, No = comparative advantage neutral and Dis = Comparative Disadvantage.

Table 19 above shows that China has a comparative disadvantage in categories HS3002 and HS3004 and is comparative-advantage-neutral in all other categories. India has a comparative advantage in producing HS3004 and a disadvantage in HS3002, all other product categories are comparative-advantage-neutral. Lastly, Brazil has a comparative disadvantage in product HS3004 and is comparative-advantage neutral in all other product categories. As highlighted earlier, these results were unexpected, considering that India and China are among the notable exporters of pharmaceuticals to Africa and the rest of the world.

Similarly, Table 23 provides a summarised version of the comparative advantage results for developed countries. The table is based on Tables 24 to 31 in Appendix I. All developed countries have a comparative advantage in one or more categories.

Table 23: NRCA results for developed countries

Product code	Switzerland	Belgium	Netherlands	France	Italy	Germany	United Kingdom	United State of America
HS3001	No	No	No	Yes	No	Yes	Yes	No
HS3002	Yes	Yes	No	Yes	No	No	Dis	Yes
HS3003	No	No	No	Yes	No	No	No	No
HS3004	Yes	Yes	Yes	Yes	Yes	Yes	Dis	Dis
HS3005	No	No	No	Yes	No	No	No	No
HS3006	No	Yes	No	No	No	Yes	No	No

Source: Author's own computation derived from Tables 24-31 in Appendix I.
*Note: Yes = comparative advantage, No = comparative advantage neutral and Dis = Comparative Disadvantage.

Table 23 shows that Switzerland has a comparative advantage in product categories HS3002 and HS3004 and is comparative advantage neutral in all other product categories. Similarly, Belgium has a comparative advantage in producing HS3002, HS3004, and HS3006 and is comparative-advantage neutral in all other product categories. Netherlands and Italy only have a comparative advantage in category HS3004 and comparative-advantage neutral in all other product categories. France has a comparative advantage in all product categories and is comparative-advantage neutral in HS3006. The United Kingdom (UK) has a comparative advantage in producing product categories HS3005 and HS3003, a disadvantage in producing HS3004 and HS3002, and comparative-advantage neutral in HS3001 and HS3006. Germany has a comparative advantage in categories HS3006, HS3004, and HS3002, the remaining categories are comparative-advantage neutral. Lastly, the United States of America (USA) has a comparative advantage in product category HS3002, a disadvantage in category HS3004, and comparative-advantage neutral in all other categories. Like the emerging countries, the results for developed countries were unanticipated because these countries are home to most African pharmaceutical imports.

These results are consistent with Mahajan *et al.* (2015) that India lags behind Belgium and Switzerland and that the UK is one of the world leaders in pharmaceutical trade. However, one would have expected the UK to have a strong comparative advantage in producing pharmaceuticals, which was not the case. The lack of comparative advantage in the UK confirms the classic view that countries do not always trade according to their comparative advantage (Leamer, 1980; Dornbusch *et al*., 1977). This view is based on four major factors,

such as: (i) Strategic trade policies support industries for national security or strategic reasons, encouraging exports in non-advantageous areas (Krugman, 1986); (ii) Government policies like subsidies, tariffs, and trade agreements often influence trade flows, enabling exports in sectors that may not naturally be competitive (IMF, 2023); (iii) Economies of scale can make large-scale production cost-effective, allowing countries to become competitive exporters despite lacking comparative advantage (Porter, 2011); (iv) Historical and cultural trade ties often sustain export relationships, even when a country does not have a production edge (Irwin, 2019). These factors highlight how the complexity of economic, political, and social considerations shape international trade. For example, countries such as India, China, the UK, and the USA are significant exporters of pharmaceuticals, despite lacking a strong comparative advantage. This suggests that while having a comparative advantage in production is important, African countries need not possess a comparative advantage in pharmaceutical production to enhance their export capacities.

6.5.2 Results for Cross-commodity Analysis.

As indicated in the methods section, the $NRCA_{ij}$'s cross-commodity feature allows the comparison of commodity groups within the country. This indicates commodity categories that are produced more efficiently in each country. Given that the comparison is within the country and acknowledging that countries do not necessarily trade according to their comparative advantages, it is expected that in some cases, countries may show efficiency in producing goods that do not align with their comparative advantage as per $NRCA_{ij}$ results. Noteworthy, this section only focuses on discussing African countries in more detail because the study is based on South Africa, however, reference will be made to emerging and developed countries as needed. Additionally, for reporting purposes, the results are presented in periods of five years, as shown in Appendix J, from Table 32 to 38.

The cross-commodity comparison results show that, on average, South Africa, Nigeria, Kenya, and Algeria produce HS3005 and HS3001 products more efficiently, with a comparative disadvantage in HS3004 and HS3002. Efficiency in the production of HS3003 and HS3006 is constantly changing over time. Egypt has a comparative advantage in producing HS3004 and HS3003 products with a disadvantage in HS3001. Morocco has a comparative advantage in producing HS3004 and HS3005 products with a disadvantage in HS3001. Lastly, Tunisia has a comparative advantage in producing HS3006 and HS3005 and a disadvantage in HS3004. The results of the cross-commodity comparison revealed a level of complementarity within African

countries whereby a country has a comparative disadvantage, matching a comparative advantage in another country.

For instance, South Africa, Nigeria, Kenya, and Algeria have a comparative disadvantage in producing HS3004, while Egypt and Morocco have a comparative advantage. These differences in pharmaceutical production capabilities highlight the critical issue of low levels of complementarity among African nations, as Stuart (2023) pointed out. Stuart (2023) further posits that Africa's current production structures often overlap instead of complementing each other, which constrains intra-African trade. Despite this, there is still significant potential to boost trade in pharmaceuticals within the continent. Improved trade integration and cooperation could help address supply gaps, reduce reliance on external markets, and ensure equitable access to essential medicines.

For instance, as efficient producers of HS3004, Egypt and Morocco can act as regional hubs for pharmaceutical manufacturing and distribution. Countries like South Africa and Nigeria, which are inefficient in producing products in this category, could import these pharmaceuticals from within the continent rather than sourcing them externally. Such arrangements would improve Africa's self-reliance and reduce vulnerabilities to global supply chain disruptions. This is particularly crucial given Africa's heavy dependence on imported pharmaceuticals. Over 70% of medicines consumed in Africa are imported, mainly from regions like Europe and Asia (McKinsey, 2019).

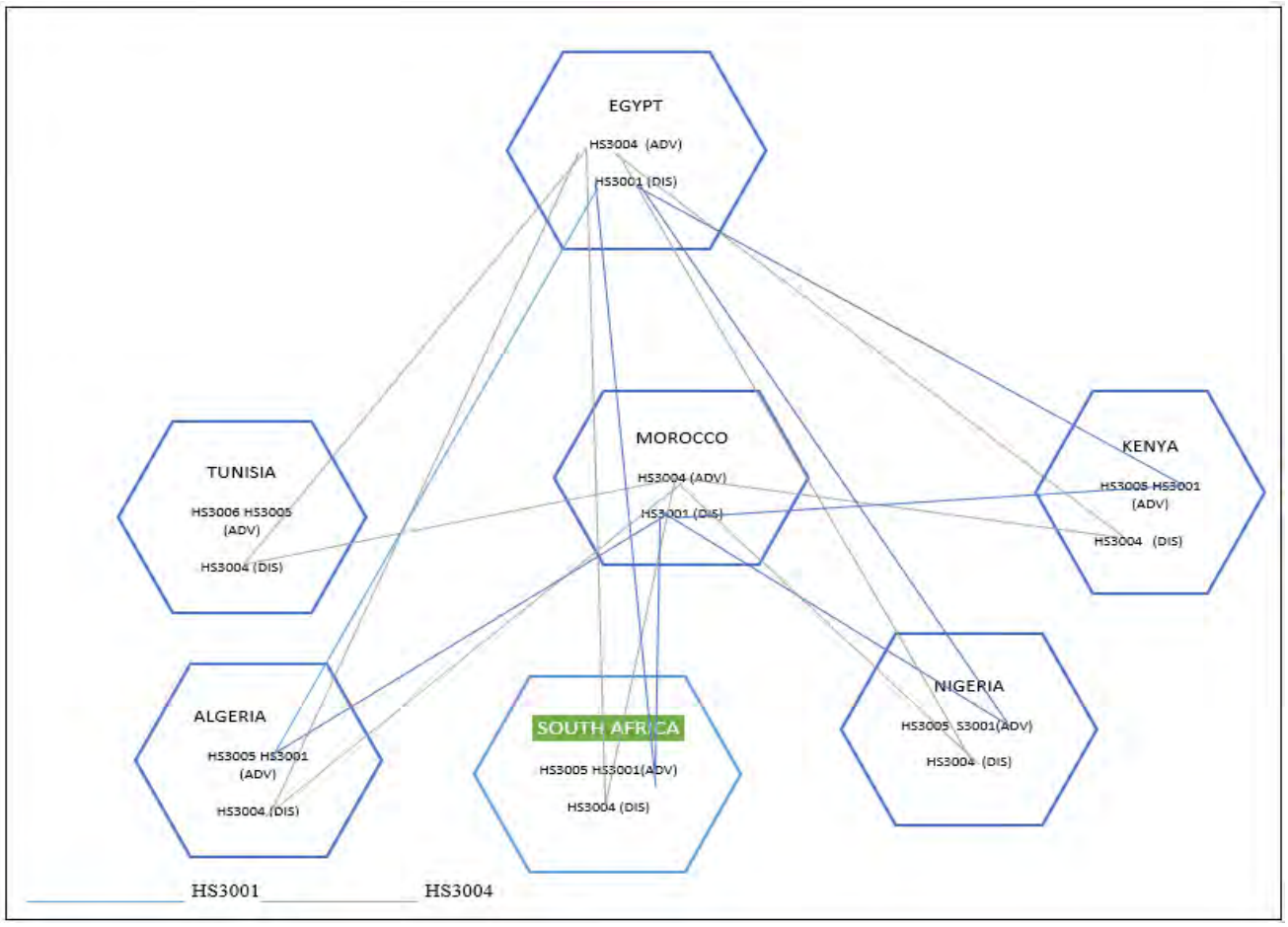

Figure 16. African countries with matching efficiencies and inefficiencies in producing HS3001, HS3004, HS3005 and HS3006.
Source: Owner's own construction
*Note: The grey line indicates matching efficiencies and inefficiencies for product category HS3004.
The blue line indicates matching efficiencies and inefficiencies for product category HS3001

Matches between countries that are efficient and inefficient in producing HS3004 and HS3001, as shown in Figure 16 above represent opportunities for regional trade partnerships, where efficient producers like Egypt and Morocco could supply pharmaceuticals to countries struggling with production inefficiencies. By creating such trade linkages, African countries could achieve greater healthcare resilience, ensuring affordable healthcare access to vital medicines. The potential of enhancing regional self-reliance in the pharmaceutical industry could be a catalyst for achieving economic autonomy in Africa. This could not only support the wider goals of economic integration within the continent but also offer a chance for countries to capitalize on their unique strengths and capabilities in the pursuit of collective self-sufficiency. As the pharmaceutical sector is crucial for public health and economic development, promoting collaboration and trade may contribute to a stronger and more self-reliant Africa. Moreover, initiatives such as the African Continental Free Trade Area (AfCFTA) provide an opportunity to foster regional integration by eliminating tariffs, harmonizing trade

policies, and encouraging investments in pharmaceutical manufacturing. Abdo and Kessy (2022) predict that AfCFTA could enhance trade flows, creating a more efficient allocation of resources across African economies. Additionally, capacity-building programs, technology transfers, and investments in research and development (R&D) can further strengthen pharmaceutical production capabilities in countries facing comparative disadvantages.

Furthermore, the cross-commodity results also showed that emerging and developed countries have a comparative disadvantage in product groups that match a comparative advantage in some African countries. Brazil and China showed inefficiency in producing HS3004 among emerging countries, while Egypt and Morocco showed efficiency in this product category. India showed inefficiency in producing HS3006, which Tunisia is efficient in producing. A summary of efficiencies and inefficiencies in the production of different pharmaceutical products for all selected countries can be summarised in Figure 17 below.

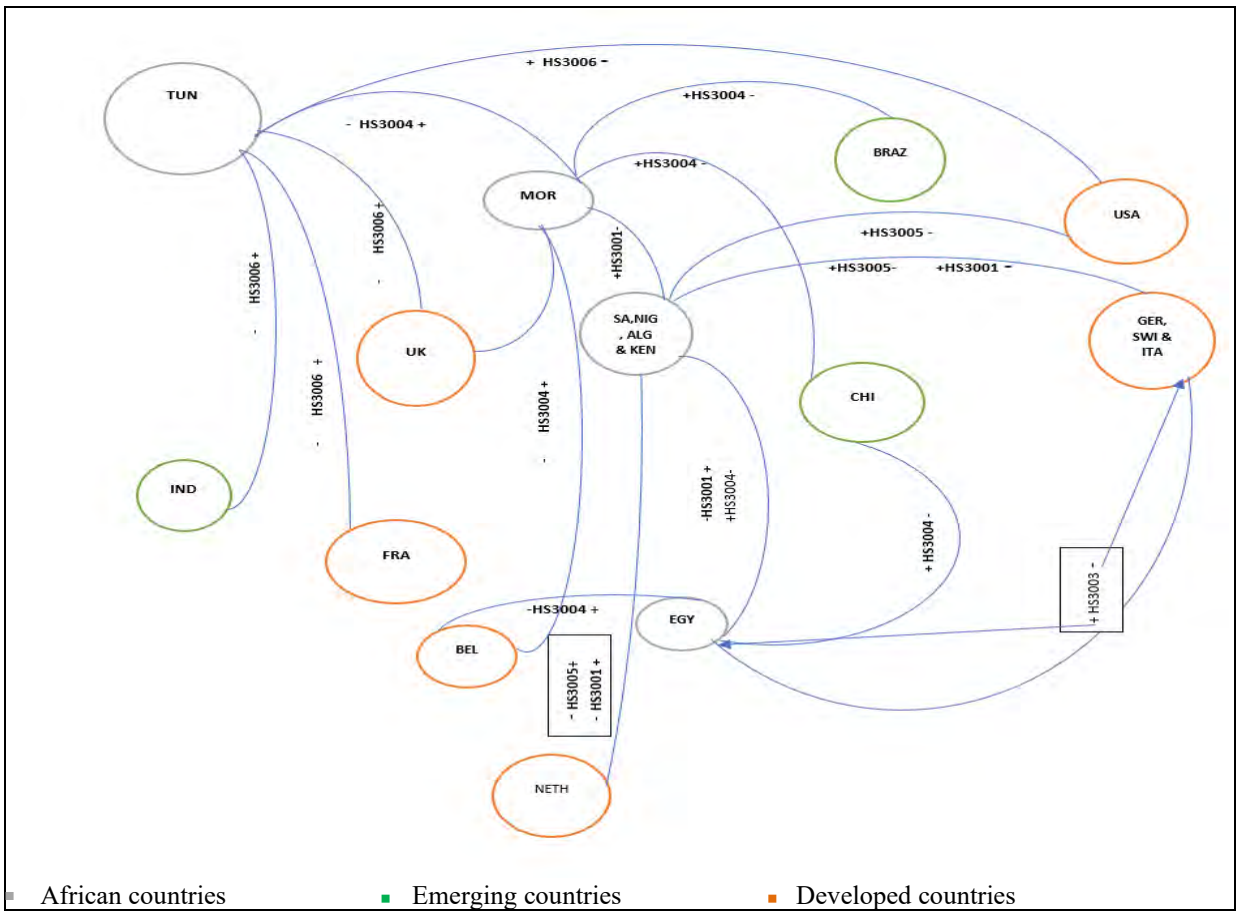

Figure 17. Matching efficiencies and inefficiencies for all selected countries

Source: Author's own construction.

Note: *(i) Positive sign (+) means comparative advantage, and negative (-) means a comparative disadvantage.
(ii) A sign placed in the direction of a particular country indicates a comparative advantage or disadvantage in that country.

Among developed countries, Figure 17 shows that Germany, Switzerland, Italy, and the Netherlands have a comparative disadvantage in producing HS3001 and HS3005, while South Africa, Nigeria, Algeria, and Kenya have a comparative advantage. The USA has a comparative disadvantage in producing HS3005 and HS3006 that matches a comparative advantage in South Africa, Nigeria, Algeria, Kenya, and Tunisia. The UK and Belgium have a comparative disadvantage in producing HS3006 and HS3004, while Tunisia, Morocco, and Egypt have a comparative advantage.

6.5.3 Results for Cross-country and temporal (over-time) comparison

The cross-country comparison measures the relative performance of the two countries in each commodity group. Due to the fact that the study is based in South Africa, this section will focus on comparing South Africa to selected African trading partners. However, highlights of the comparison with emerging and developed countries are provided. The results reveal that when compared to African countries, South Africa shows some comparative advantage only over Nigeria and Algeria (Appendix K, Tables 37- 43). The comparative advantage over Nigeria is inconsistent, with shifts between different product groups each year. The comparative advantage over Algeria is steadily on HS3003 and occasionally over HS3005 and HS3006. However, the comparative advantage is mainly observable from 2001 to 2015 for Nigeria and from 2001 to 2011 for Algeria. From 2016 to 2022, South Africa lost its comparative advantage over both countries. The loss of comparative advantage coincides with the timeframe when the TAC launched the “Fix the patent laws” campaign because of the high prices of chronic medicines (Tomlinson, 2019). This implies that poor patent management, which led to high medicine prices, made it difficult to compete globally, contributing to a decrease in comparative advantage.

The results also showed that South Africa possesses a comparative advantage over most product categories compared to emerging countries. Throughout the period of study, South Africa consistently shows a comparative advantage in four product categories over China (HS3005, HS3004, HS3003, and HS3002) and India (HS3006, HS3005, HS3001, and HS3002) while also showing a comparative advantage in five product groups over Brazil, except for HS3001. Compared to developed countries, South Africa has a comparative advantage in producing HS3001 and HS3005 over Belgium, Germany, and occasionally Switzerland and Italy. South Africa also shows a consistent comparative advantage in producing HS3001 and HS3003 over Germany and HS3004 over the USA. These results were unexpected, considering South Africa depends on imported pharmaceutical products, mostly from emerging and developed countries.

The possible explanation for the unexpected outcomes is that while more than 60% of pharmaceutical products sold in South Africa are formulated locally, approximately 98% of Active Pharmaceutical Ingredients (APIs) used in local formulations are imported. Currently, 100% of APIs used to formulate ARVs are imported (DTI 2023). Therefore, South Africa might have a comparative advantage over some countries because the data used in this study is collected from the trade of products regardless of the source of inputs. The global decomposition of supply chains requires that we isolate the value-added a country contributes to the production of a good in order to reflect the true comparative advantage of nations (Dai, 2013). On another note, the high import demand for APIs shows a substantial market opportunity for local manufacturing of APIs in South Africa. If a significant portion of APIs can be manufactured domestically, the country can capitalize on its areas of comparative advantage. Tunisia, Egypt, and Morocco show a comparative advantage in most product categories overall African and emerging countries. These three countries also show a considerable comparative advantage over many developed countries. These findings indicate that African countries have the potential to integrate into the global pharmaceutical value chain and compete effectively.

Lastly, the results of the temporal comparison over time for African countries (Appendix L, Tables 44-50) revealed that there has been a general decrease in comparative advantage in South Africa and Nigeria. Other African countries experienced a steady increase in comparative advantage in all product categories over time. This is another interesting finding, which affirms that African countries can position themselves as notable players in the global pharmaceutical trade.

6.5.4 Trade Complementarity Results

Following the robust analysis of comparative advantage in the production of pharmaceuticals, the next step is to look at the complementarity of pharmaceutical trade between South Africa and its trading partners using the TCI. The TCI results complement the $NRCA_{ij}$ by measuring how well a country's export profile aligns with the import needs of its trading partners. It is insufficient to rely solely on matching comparative advantages and disadvantages (as illustrated in Figures 15 and 16 above) as a foundation for a potential trade. If the import requirements of one trading partner do not correspond with the export capabilities of another, trade potential diminishes. Therefore, the results in this section provide a clear picture of potential trade in pharmaceuticals between South Africa and selected African and emerging countries. Table 53

below shows high complementarity between South Africa's pharmaceutical exports and imports from its emerging trading partners, ranging from 62% to 90%.

Table 53: TCI results for South African exports and imports by emerging countries

Product Code	|SA EXP-CHINA IMP|/2		|SA EXP-INDIA IMP|/2		|SA EXP-BRAZIL IMP|/2	
	Value in 2022	Value in 2023	Value in 2022	Value in 2023	Value in 2022	Value in 2023
'3001	0.003	0.001	0.020	0.012	0.002	0.000
'3002	0.042	0.128	0.025	0.122	0.039	0.185
'3003	0.018	0.026	0.007	0.010	0.015	0.023
'3004	0.065	0.081	0.011	0.121	0.016	0.138
'3005	0.016	0.028	0.012	0.022	0.016	0.027
'3006	0.009	0.006	0.020	0.019	0.006	0.003
Total	**0.153**	**0.270**	**0.095**	**0.308**	**0.093**	**0.375**
1 - Total	**0.847**	**0.730**	**0.905**	**0.692**	**0.907**	**0.625**
***100**	**84.691**	**73.021**	**90.468**	**69.232**	**90.661**	**62.465**

Source: Author's own computation using data from Trade Map (2023)

The study further examined how South African pharmaceutical imports match exports of selected emerging countries. Table 54 below shows high complementarity between South Africa's pharmaceutical imports and pharmaceutical exports by emerging partners, ranging from 62.7% to 84.7%. However, there is also a significant decrease of more than 10% across the three countries from 2022 to 2023. This could indicate a shift in pharmaceutical demands after COVID-19 as countries learned to cope with the available pharmaceutical supplies in the face of stringent lockdowns.

Table 54: TCI results for South African imports and exports by emerging countries

Product Code	|SA IMP-CHINA|/2		|SA IMP-INDIA|/2		|SA IMP-BRAZIL|/2	
	Value in 2022	Value in 2023	Value in 2022	Value in 2023	Value in 2022	Value in 2023
'3001	0.0634	0.0493	0.0018	0.0015	0.0429	0.0385
'3002	0.0415	0.0726	0.0767	0.0685	0.0124	0.0496
'3003	0.0375	0.0432	0.0078	0.0057	0.0008	0.0010
'3004	0.1451	0.1077	0.0882	0.0866	0.0692	0.0257
'3005	0.0726	0.0775	0.0079	0.0090	0.0110	0.0068
'3006	0.0132	0.0104	0.0132	0.0163	0.0285	0.0311
Total	**0.3732**	**0.3606**	**0.1956**	**0.1878**	**0.1648**	**0.1526**
1 - Total	**0.6268**	**0.6394**	**0.8044**	**0.8122**	**0.8352**	**0.8474**
***100**	**62.6794**	**63.9403**	**80.4423**	**81.2246**	**83.5163**	**84.7386**

Source: Author's own computation using data from Trade Map (2023)

There is a slight increase of less than 2% from 2022 to 2023 across all countries, implying that there has not been a significant shift in the bucket of South African pharmaceutical imports and the emerging countries' exports post-COVID-19. The steadiness in complementarity is good for future trade as it means there would be no or few instances of unexpected changes in

trade demands. On the contrary, the trade complementarity between the South African pharmaceutical exports and imports of African countries is relatively low, ranging from the lowest of 14% to the highest of 79%, as shown in Table 55 below.

Table 55: TCI of SA's pharmaceutical exports with imports by African countries

	|SA EXP-NIG|/2		|SA EXP-EGY|/2		|SA EXP-MOR|/2		|SA EXP-ALG|/2		|SA EXP-TUN|/2		|SA EXP-KENY|/2	
Product Code	**Value in 2022**	**Value in 2023**	**Value in 2022**	**Value in 2023**	**Value in 2022**	**Value in 2023**	**Value in 2022**	**Value in 2023**	**Value in 2022**	**Value in 2023**	**Value in 2022**	**Value in 2023**
'3001	0.0004	0.0011	0.0185	0.0021	0.0039	0.0023	0.0061	0.0072	0.0369	0.0155	0.0005	0.0003
'3002	0.3223	0.0662	0.2321	0.1675	0.3568	0.0609	0.1617	0.1406	0.3145	0.0213	0.2726	0.0502
'3003	0.0229	0.0295	0.0483	0.0338	0.0328	0.0523	0.0293	0.0220	0.3166	0.3048	0.0457	0.0612
'3004	0.3512	0.1217	0.1779	0.1766	0.4238	0.1742	0.1903	0.0977	0.0321	0.2724	0.3161	0.0125
'3005	0.0223	0.0448	0.0299	0.0519	0.0386	0.0607	0.0308	0.0518	0.0314	0.0537	0.0239	0.0402
'3006	0.0167	0.0200	0.0173	0.0251	0.0005	0.0026	0.0253	0.0237	0.0245	0.0272	0.0266	0.0390
Total	**0.7359**	**0.2834**	**0.5240**	**0.4570**	**0.8564**	**0.3528**	**0.4435**	**0.3431**	**0.7560**	**0.6950**	**0.6854**	**0.2034**
1 - Total	**0.2641**	**0.7166**	**0.4760**	**0.5430**	**0.1436**	**0.6472**	**0.5565**	**0.6569**	**0.2440**	**0.3050**	**0.3146**	**0.7966**
***100**	**26.4090**	**71.6643**	**47.6009**	**54.2968**	**14.3608**	**64.7162**	**55.6537**	**65.6905**	**24.4010**	**30.5027**	**31.4603**	**79.6580**

Source: Authors own computation using data from Trade Map (2023)

Table 55 shows that trade complementarity generally improved from 2022 to 2023 across all countries, with significant improvements observed between South Africa and (i) Nigeria (from 26% to 71.6%); (ii) Morrocco (from 14% to 64.7%); (iii) Kenya (31% to 79.7%). The increase in trade complementarity between African countries shows potential for increased pharmaceutical trade intensity in the African region. Similarly, Table 56 above shows high complementarity between South African pharmaceutical imports and pharmaceutical exports of African countries.

Table 56: TCI results for South African imports and exports by African countries

	|SA IMP-NIG|/2		|SA IMP-EGY|/2		|SA IMP-MOR|/2		|SA IMP-ALG|/2		|SA IMP-TUN|/2		|SA IMP-KENY|/2	
Product Code	**Value in 2022**	**Value in 2023**	**Value in 2022**	**Value in 2023**	**Value in 2022**	**Value in 2023**	**Value in 2022**	**Value in 2023**	**Value in 2022**	**Value in 2023**	**Value in 2022**	**Value in 2023**
'3001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.003	0.002
'3002	0.114	0.108	0.103	0.072	0.083	0.077	0.106	0.102	0.106	0.101	0.191	0.204
'3003	0.371	0.207	0.009	0.005	0.002	0.002	0.002	0.002	0.000	0.000	0.002	-0.009
'3004	0.226	0.065	0.037	0.008	0.085	0.086	0.126	0.137	0.070	0.063	0.235	0.235
'3005	0.010	0.011	0.075	0.076	0.020	0.015	0.001	0.011	0.000	0.001	0.011	0.006
'3006	0.019	0.022	0.016	0.017	0.019	0.021	0.015	0.021	0.037	0.040	0.028	0.031
Total	**0.371**	**0.000**	**0.120**	**0.090**	**0.105**	**0.101**	**0.252**	**0.275**	**0.215**	**0.103**	**0.470**	**0.469**
1 - Total	**0.629**	**1.000**	**0.880**	**0.910**	**0.895**	**0.899**	**0.748**	**0.725**	**0.785**	**0.897**	**0.530**	**0.531**
***100**	**62.934**	**100.000**	**87.963**	**91.013**	**89.463**	**89.910**	**74.826**	**72.540**	**78.460**	**89.658**	**53.045**	**53.073**

Source: Author's own computation using data from Trade Map (2023)

The high complementarity is mainly driven by product categories '3004 and '3002. There is also a slight change from 2022 to 2023, except for Nigeria, which jumped from 62.9% to 100%, implying potential for more future trade with a few unexpected changes in trade.

6.6 Discussion of results

While many countries were examined due to the comparative nature of the study, the primary focus of the study was to investigate South Africa's comparative advantage. Hence, the subsequent points aim to illuminate conditions in South Africa that could have contributed to the lack of comparative advantage in the production of pharmaceuticals. First, the industry requires high research and development (R&D) to develop new drugs and medical technologies, necessitating funding and conducting extensive clinical research. The number of trials in South Africa remains far behind that of developed countries despite the significant contribution of multinational companies (MNCs) to R&D, clinical research, and manufacturing. For instance, the United Kingdom has more than six times the number of trials per capita compared to South Africa (Innovative Pharmaceutical Association South Africa, 2019). Therefore, it is critical for pharmaceutical companies for pharmaceutical manufacturers to have access to capital.

As highlighted in Chapter 2, some of the challenges that reduce South Africa's comparative advantage in producing pharmaceuticals include weak patent laws that allow "evergreening," where patents are extended through minor modifications. This keeps medicine prices high and limits the country's comparative advantage in exports (Rayment, 2020). Regulatory delays also hinder competitiveness. Although the risk-based assessment process has reduced drug approval times from over 2000 to 511 days, South Africa still trails peers like China, India, and Egypt in efficiency (Moeti *et al*., 2023; Su *et al*., 2022). Many other factors contribute to the low comparative advantage in South Africa. However, improving the ones discussed above would make a significant difference.

6.7 Summary and Conclusion

This chapter examined the comparative advantage and trade complementarity between South Africa and its trading partners. The $NRCA_{ij}$ and TCI results offer a comprehensive understanding of trade dynamics by combining insights on comparative advantage with alignment in trade needs. The $NRCA_{ij}$ identified the product categories where a country holds a comparative advantage, highlighting areas of potential specialisation. However, while $NRCA_{ij}$ reveals the sectors where a country can compete globally, it does not account for whether these

exports meet the specific import demands of trading partners. The TCI complements this by measuring how well a country's export profile aligns with the import needs of its target markets. Therefore, this chapter provided a deeper, dual-layered analysis that showed South Africa's potential competitive products in pharmaceuticals and also assessed how effectively the exports of these products meet the needs of trading partners in emerging and African markets. The results are helpful for policymakers and businesses to identify high-potential markets and ultimately enhance intra-industry trade in the South African pharmaceutical sector and within Africa.

Chapter 7

Determinants of Absorptive Capacity and its Impact on Intra-Industry Trade and Growth in South Africa's Pharmaceutical Sector.

7.1 Introduction

This chapter discusses the empirical methodology adopted to address the primary objectives of the study. These objectives are stated as follows: (i) Identifying the determinants of absorptive capacity in the South African pharmaceutical industry, (ii) Establishing the relationship between intra-industry trade and Absorptive Capacity, and (iii) Determining the effect of absorptive capacity and intra-industry trade on the growth of the South African pharmaceutical sector. The Structural Equation Model (SEM) is appropriate for examining the nature of these relationships. The SEM is a statistical technique for testing and estimating the causal relationship based on statistical data and qualitative causal assumptions (Urbach & Ahlemann, 2010). SEM has two major techniques: The Partial Least Squares (PLS) and the Covariance Based (CB). The CB-SEM focuses on theory testing and model fit, while PLS focuses on prediction and the maximization of explained variance in the dependent variables. This study employs PLS-SEM because it can handle complex models and is robust to violations of statistical assumptions, such as normality and multicollinearity. It also allows for rigorous testing of reflective and formative constructs, providing strong predictive insights while relying less on large sample sizes. Therefore, the chapter starts by conducting Factor Analysis (FA), followed by PLS-SEM analysis, and lastly, a PLS-SEM-Mediation model to achieve its objectives using the data extracted from the SARB and World Development Indicators (WDI) for the period 2002-2021.

7.2 Factor Analysis

The factor analysis summarises data so that relationships and patterns can be easily interpreted and understood. It is normally used to regroup variables into limited clusters based on shared variance (Yong & Pearce, 2013). Specifically, this study uses Confirmatory Factor Analysis (CFA) because it tests whether a specified set of constructs is influencing responses in a predicted way. CFA is a specialized statistical technique used within the structural equation modeling framework to test the hypotheses about the relationships between observed measures or *indicators* (e.g., test items, test scores, behavioural observation ratings) and latent variables or *factors* (Brown, 2006). The goal of latent variable measurement models (i.e., factor analysis) is to establish the number and nature of factors that account for the variation and covariation

among a set of indicators. A factor is an unobservable variable that influences more than one observed measure and accounts for the correlations among these observed measures.

CFA is grounded in the common factor model, which posits that the variance observed in a set of measured variables can be attributed to a smaller number of underlying latent factors and some measurement error. The technique is particularly valuable in validating measurement models, assessing the construct validity of instruments, and testing the relationships between latent variables and their indicators (Thurstone, 1947). Figure 18 below presents the structure of the Factor analysis for this study.

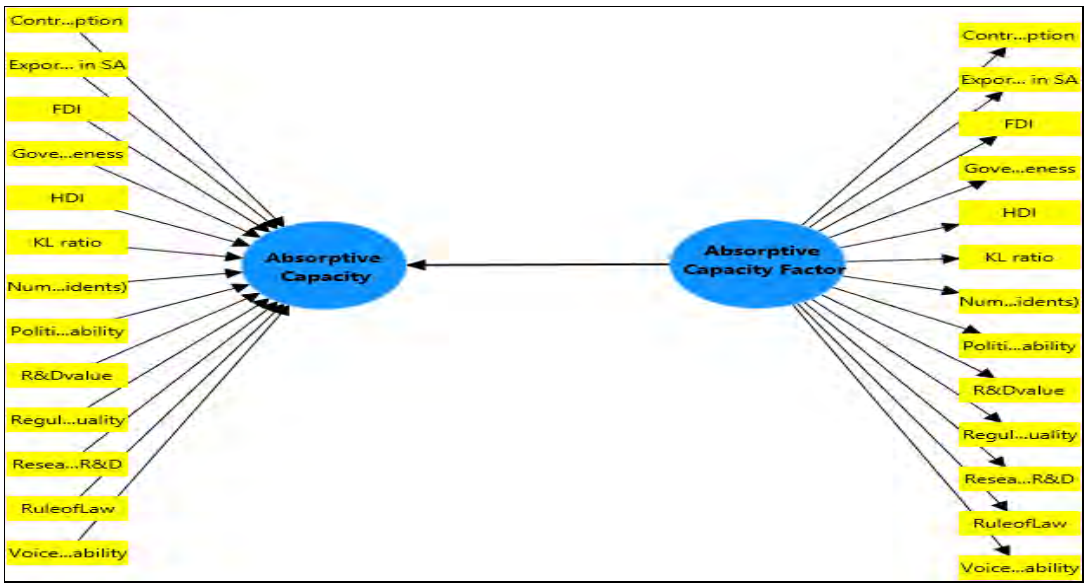

Figure 18: Factor Analysis Source: Authors results

The process of conducting CFA typically involves six key steps (Kline, 2023; Brown, 2006 and Hu & Bentler, 1999): First is a model specification, which defines the factor model by specifying the number of factors and the expected pattern of factor loadings. A factor loading for a variable measures how much the variable contributes to the factor; thus, high factor loading scores indicate that the variables better account for the dimensions of the factors (Yong & Pearce, 2013). That is, how each observed variable relates to the underlying latent constructs. According to (Hu & Bentler, 1999), The model can be represented as:

$$X=\lambda_{ij} F+\epsilon \quad \ldots\ldots (9)$$

Where:

- X is the vector of observed variables.

- λ_{ij} (lambda) is the matrix of factor loadings, which represents the relationships between observed variables and latent factors.
- F is the vector of latent factors.
- ϵ is the vector of measurement errors.

The factor loadings (λ_{ij}) are estimated to indicate the strength and direction of the relationship between the i^{th} observed variable and the j^{th} latent factor. The model also includes error variances (ϵ_i) for each observed variable, reflecting the variance not explained by the latent factors.

These specifications are guided by existing theory or prior empirical findings (Brown, 2006). Second is the data collection, which involves gathering data on the observed variables. It is crucial to have a sufficiently large sample size, as CFA models are sensitive to sample size. Typically, larger samples provide more reliable and generalizable results (Kline, 2023). Third is model estimation, which involves estimating the model parameters, such as factor loadings and error variances. It is generally done using maximum likelihood estimation (MLE), the most common estimation method. However, if the data violates normality assumptions, alternative methods such as Asymptotically Distribution-Free (ADF) estimation may be used (Brown, 2006).

Fourth is the model evaluation using various goodness-of-fit indices. This is a critical aspect of CFA because poor model fit suggests that the hypothesized model does not adequately capture the data's underlying structure, potentially indicating problems with the theory or the measurement instrument. Goodness-of-fit indices provide different perspectives on model fit. This study will use R-squared (R^2) to evaluate goodness-of-fit. Fifth, model modification is undertaken if the initial model does not fit well. Modifications might involve adding or removing paths between variables and factors. However, it is critical that these modifications are theoretically justified rather than being driven purely by statistical considerations (Brown, 2006). Sixth, reporting and interpretation should be reported, including the fit indices, factor loadings, and any model modifications.

Other evaluation techniques include Composite Reliability (CR), Convergent Validity measured by the Average Variance Extracted (AVE), and discriminant validity measured by the Fornell-Larcker Criterion. The CR measures the internal consistency of a latent variable for which values above 0.7 indicate good reliability. The AVE Measures the amount of variance

captured by a latent variable from its indicators. The AVE should be above 0.5 to indicate that the latent variable explains more than half the variance of its indicators. Lastly, the Fornell-Larcker criterion helps confirm discriminant validity by comparing the square root of AVE for each latent construct with its correlations with other constructs. The square root of the AVE should be higher than the correlation with other constructs for a construct to be distinct and have good discriminant validity.

CFA is widely used in social sciences to validate the factor structure of instruments. It is particularly useful in confirming that a set of observed variables accurately reflects the intended latent constructs. Despite its strengths, CFA has limitations. It requires large sample sizes, and the results can be sensitive to violations of assumptions such as normality. Additionally, while CFA is excellent for confirming hypothesized structures, it does not explore new factor structures, making it less flexible than Exploratory Factor Analysis (EFA) in certain contexts (Brown, 2006; Kline, 2016). The CFA is an important precondition for running a PLS-SEM because it ensures that the measurement models are valid, the constructs are theoretically sound, and the overall model specification is accurate.

7.3 The PLS-SEM Model

PLS-SEM was developed as a soft modelling approach that does not impose strict assumptions about data distribution. This characteristic makes it particularly useful when the data does not meet the normality assumptions required by CB-SEM (Wold, 1982). Lohmöller (1989) refined the PLS-SEM technique, making it more accessible and applicable in various research contexts. Since then, scholars like Hair *et al*.(2014; 2022) have extensively contributed to developing and disseminating PLS-SEM through their comprehensive guides and textbooks on the subject.

One of the most significant advantages of PLS-SEM is its flexibility. PLS-SEM is not limited by strict sample size requirements, which makes it an attractive option for studies with small sample sizes (Hair *et al*., 2017). Additionally, PLS-SEM can handle formative and reflective measurement models, making it versatile in complex research designs (Vinzi *et al*., 2010). This flexibility extends to the types of data PLS-SEM can analyze, including non-metric data, which broadens its applicability in various research settings (Matthews *et al*., 2018). Over the years, literature has seen significant advancements in PLS-SEM's application and methodological development. For instance, the introduction of the cross-validated predictive ability test (CVPAT) by Liengaard *et al*. (2021) represents a novel advancement in evaluating the

predictive power of PLS models. This development is crucial as it shifts some focus of PLS-SEM from purely explanatory modelling to predictive accuracy (Shmueli *et al*., 2019).

This study will conduct the PLS-SEM using the variables as guided by the literature discussed in Chapter 4. Absorptive Capacity is a latent construct that will be measured using Research and Development (R&D), Foreign Direct Investment (FDI), Human Development Index (HDI), Level of Trade Barriers, Patent Applications, Exported Growth, Intra- Industry Trade, Capital and Labour ratio, and the quality of institutions as observable indicators. The quality of institutions is proxied by Political Stability, Regulatory Quality, Rule of Law, Accountability, Control of Corruption, and Government Effectiveness. Export Growth is a proxy for growth in the pharmaceutical sector. These variables are further clustered into the four factors of Absorptive Capacity: acquisition, assimilation, transformation, and exploitation, as in Figure 19 below.

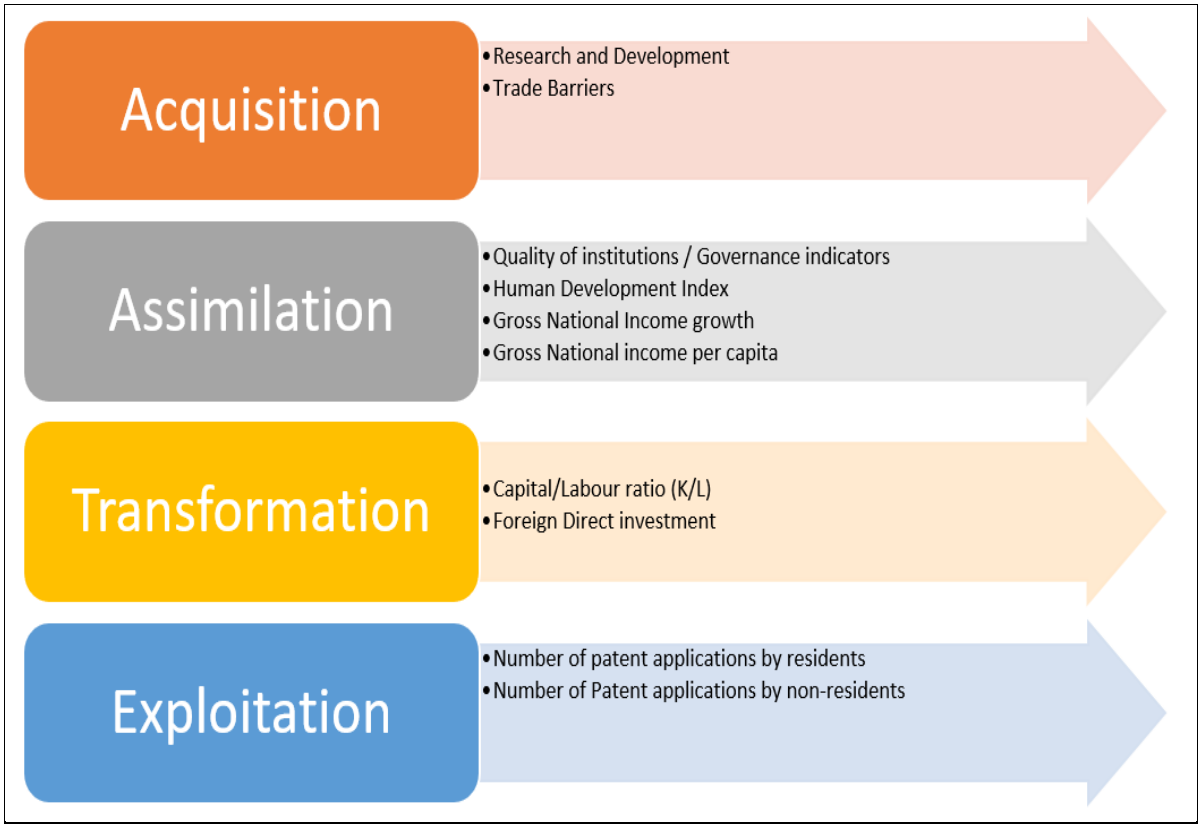

Figure 19. Absorptive Capacity in the South African Pharmaceutical Sector

Source: Author's own construction

The rationale for such clustering is as follows:

Acquisition: R&D directly contributes to the creation and acquisition of new knowledge, enhancing the capacity to identify and internalize valuable external information (Cohen & Levinthal, 1989). Moreover, R&D promotes a culture of innovation and continuous learning, which is vital for effective knowledge acquisition (Zahra & George, 2002). Trade barriers influence absorptive capacity by controlling the flow of external knowledge and stimulating domestic R&D efforts. While immediate access to foreign technologies may be restricted if set relatively high, trade barriers can encourage the development of domestic capabilities, allowing organizations or countries to selectively acquire knowledge that aligns with their strategic objectives (Narula, 2004).

Assimilation: The Quality of Institutions[16], Human Development Index (HDI), Gross National Income (GNI) growth, and GNI per capita represent governance and economic indicators that are critical components in the assimilation aspect of absorptive capacity. Considering governance indicators, if institutions are reliable, transparent, and efficient, they create an environment conducive to the smooth assimilation of knowledge. For instance, Control of Corruption and the Rule of Law are essential for ensuring that the mechanisms for absorbing external knowledge are free from corrupt practices and that legal frameworks are robust enough to protect intellectual property and enforce contracts, which are fundamental for the effective utilization of new knowledge (Kaufmann *et al*., 2010). Similarly, Government Effectiveness and Regulatory Quality reflect the capability of public institutions to implement policies that facilitate the integration of external knowledge into the domestic economy (World Bank, 2020). Political stability creates an economy conducive to long-term investments in knowledge and innovation without the disruptions caused by political turmoil (Alesina *et al*., 1996). Voice and Accountability ensure a participatory approach to governance, where stakeholders can express their needs and contribute to decision-making processes, enhancing the relevance and applicability of assimilated knowledge (Rodrik, 2000).

Considering economic indicators, higher GNI per capita enables greater access to education, information technologies, and professional development, which are key to improving the internal absorption and application of knowledge. Populations with higher income levels are

[16] Indicated by Control of Corruption, Government Effectiveness, Political Stability, Regulatory Quality, Rule of Law, Voice, and Accountability

more likely to be technologically literate and can provide a skilled labour force better equipped to integrate new knowledge into productive systems (Narula, 2004). HDI is directly linked to the ability of individuals and firms to interpret, adapt, and apply knowledge, which enhances the assimilation process (Cohen & Levinthal, 1989; Zahra & George, 2002). Sustained GNI growth indicates expanding economic activity and often correlates with increased investments in infrastructure, technology, and education systems. A growing economy is more likely to have the institutional and financial capacity to support knowledge transfer, innovation systems, and training, which are critical for embedding and operationalizing new knowledge. Moreover, economic growth fosters organizational learning and encourages firms to improve internal processes and capabilities that facilitate assimilation (Kneller & Stevens, 2006). Furthermore, HDI, GNI growth, and GNI per capita reflect a country's overall economic well-being and capacity to invest in education, health, and infrastructure, which are crucial for effectively assimilating new knowledge (Sen, 1999). Together, these factors create a stable, transparent, and inclusive environment essential for successfully adopting and applying external knowledge, thereby enhancing absorptive capacity.

Transformation: The Capital/Labor ratio plays a crucial role in enhancing absorptive capacity through the availability of capital resources required for implementing new technologies and processes. It reflects the level of investment in advanced machinery, automation, and infrastructure, which are essential for turning acquired knowledge into productive activities (Griliches, 1998). A well-balanced Capital/Labor ratio is particularly beneficial in capital-intensive industries, such as the pharmaceutical sector, where sophisticated equipment and technology are essential for fully leveraging external knowledge (Solow, 1957). If there is an overreliance on labour without sufficient capital investment, the ability to transform knowledge may be constrained. Conversely, excessive capital without skilled labour may lead to the underutilization of technology. Thus, the interaction between capital intensity and labour quality determines how well knowledge can be transformed into innovative outputs (Griffith *et al*., 2004).

Foreign Direct Investment (FDI) is a significant driver of absorptive capacity, as it not only brings in capital but also introduces new technologies, managerial practices, and organizational know-how. FDI also facilitates the transfer of advanced knowledge from more developed economies to less developed ones, leading to the local assimilation of such knowledge into production processes (Borensztein *et al*., 1998). The presence of foreign firms can also result

in spillover effects, where local firms learn and adopt foreign technologies and practices, thereby enhancing their operations and competitiveness (Keller, 1996). Furthermore, FDI often includes training and development programs, which help the local workforce assimilate and apply new knowledge effectively, reinforcing the transformation process (Blomström & Kokko, 1998). In short, a well-balanced Capital/Labour ratio ensures sufficient capital for implementing new technologies, while FDI facilitates the transfer and adaptation of foreign knowledge, resulting in improved productivity and innovation.

Exploitation: The number of patent applications, both by residents and non-residents, is a critical indicator of the exploitation aspect of absorptive capacity, reflecting a country's ability to pull transformed knowledge into new innovations. Resident patent applications demonstrate the capacity of domestic entities to convert absorbed and transformed knowledge into patentable and marketable technologies, showing a strong internal innovation environment where knowledge is effectively utilized for competitive advantage (Griliches, 1990; Acs *et al*., 2002). On the other hand, non-resident patent applications indicate the attractiveness of the local market or legal framework for foreign innovators, suggesting that the environment is conducive to the commercialization of new technologies (Hu & Pang, 2013). Moreover, non-resident patents can lead to knowledge spillovers, where domestic firms learn from and build upon foreign innovations, further enhancing their ability to exploit knowledge (Eaton & Kortum, 1996). Together, these indicators highlight the strength of a country's capacity to harness and exploit knowledge for economic growth and innovation.

7.4 PLS-SEM Mediation Model

Another important contribution to the SEM comes from Chin *et al*. (2020) and Sharma *et al*. (2019), who developed frameworks to deal with selection uncertainty and using multiple models in PLS-SEM. This helps ensure that the results are both reliable and meaningful. These contributions are essential in ensuring the models generated are statistically robust and practically significant. Additionally, the work of Nitzl (2016) and Carrión *et al*. (2017) on mediation and moderation analysis in PLS-SEM provides detailed guidelines on using PLS-SEM to explore complex causal relationships, further cementing its utility in advanced statistical modeling. They emphasized the importance of bootstrapping[17] methods to assess the significance of indirect effects, which has become standard practice in PLS-SEM mediation

[17] Bootstrapping refers to the resampling technique used to assess the precision of model estimates, especially when the sample size is small, or the data distribution does not meet the normality assumptions.

analysis. Furthermore, the work of Preacher and Hayes (2008) on resampling methods has influenced how mediation is tested and interpreted in PLS-SEM. Moreover, recent advancements have addressed the challenges of prediction in mediated models. For instance, Shmueli *et al*. (2016) introduced an explicit algorithm for generating predictions from PLS-SEM models, which is particularly useful when mediators are involved. This predictive approach has been further developed by Danks *et al*. (2020), who explored the predictive validity of mediation models in PLS-SEM, providing insights into how these models can be used for both explanatory and predictive purposes. Predictions can be generated using the measurement indicators and structure of the model, starting with the most antecedent constructs, to predict endogenous construct scores and their measurement indicators, as in Figure 20 below.

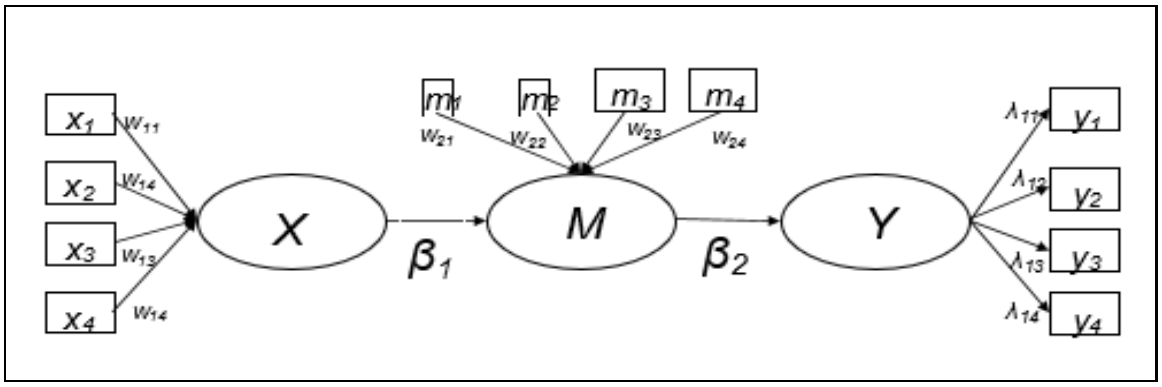

Figure 20 Fully Mediated Model Source: Danks (2020)

This process can be conceptualized for a simple model with a single antecedent construct (*X*) with measurement indicators x_i and single outcome construct (*Y*) with indicators y_i: measurement weights can be used (w_{ij}), loadings (λ_{ij}), and structural path (β) to relate the indicators of the antecedent to the indicators of the outcome.

One of the significant challenges in mediation analysis using PLS-SEM is dealing with the complexity introduced by mediators, especially in terms of model fit and predictive accuracy. Mediators increase the complexity of the model by serving as both outcomes of one variable and predictors of another, which can complicate the interpretation of results. To address this concern, recent studies have proposed various strategies for improving the robustness of mediation analysis in PLS-SEM. For example, Sarstedt *et al*. (2020) stressed the importance of considering both the direct and indirect effects when assessing the overall impact of mediators in a model. This approach ensures that the mediators' roles are accurately captured and that the conclusions drawn from the model are valid. Furthermore, the work by Hayes (2018) on

conditional process analysis has been instrumental in advancing the understanding of moderated mediation in PLS-SEM. This method allows the study to explore how the strength of the mediation effect varies across different levels of a moderator, adding another layer of complexity to mediation models and providing a more detailed understanding of the processes at play. The relevance of the mediation model in this study stems from the need to understand whether absorptive capacity is a mediator between intra-industry trade and growth in the South African pharmaceutical sector.

7.5 Presentation of results

This section presents the outcomes of data analysis, beginning with factor analysis, model evaluation, and mediation effects. The discussion starts off by presenting the descriptive statistics, followed by reliability and validity results. Next are the results of the inner and outer model evaluations, focusing on the path coefficients and goodness-of-the-fit. Lastly, the results of the mediation analysis between intra-industry trade and growth will be discussed.

7.5.1 Descriptive data analysis

Descriptive statistics provide a summary and understanding of the key features of a dataset, reflecting the distribution, central tendency, and variability of the data. This is the first step in data analysis, summarizing the main characteristics of the dataset. This helps understand the overall structure of the data, identify patterns, and ensure that the data is suitable for statistical analysis or modeling. The descriptive statistics of the data set used in this study are provided in Table 57 below.

Table 57: Descriptive statistics for the SEM Model

	Mean	Median	Observed min	Observed max	Standard deviation	Excess kurtosis	Skewness	Number of observations used	Cramér-von Mises test statistic	Cramér-von Mises p value
ControlofCorruption	0.089	0.033	-0.184	0.484	0.193	-0.747	0.577	20.000	0.081	0.189
Exported growth SA	17.600	5.500	-10.000	128.000	36.467	5.612	2.496	20.000	0.527	0.000
Exported value of pharmaceuticals in SA	329.349	397.297	83.617	894.213	194.863	1.816	0.879	20.000	0.228	0.002
FDI	1.664	1.106	0.205	9.856	2.028	13.917	3.506	20.000	0.436	0.000
GNI per capita	5625.077	5890.805	4351.267	6164.042	594.180	-0.361	-1.036	20.000	0.267	0.001
GNIgrowth	2.290	2.657	-5.178	5.601	2.424	3.147	-1.329	20.000	0.048	0.517
GovernmentEffectiveness	0.269	0.206	-0.017	0.608	0.181	-0.430	0.756	20.000	0.144	0.026
HDI	0.683	0.691	0.629	0.736	0.038	-1.661	-0.216	20.000	0.147	0.024
MIIT	-0.368	-0.835	-1.000	1.000	0.809	-0.788	1.026	20.000	0.428	0.000
Number Patent applications (Non - Residents)	6506.000	6547.500	5303.000	9156.000	803.726	4.902	1.630	20.000	0.087	0.156
Number of Patent applications (Residents)	837.150	821.500	542.000	1804.000	261.143	9.010	2.534	20.000	0.169	0.012
PoliticalStability	-0.148	-0.144	-0.707	0.215	0.184	3.249	-0.970	20.000	0.056	0.404
R&D	0.706	0.699	0.604	0.806	0.062	-1.077	0.022	20.000	0.062	0.336
RegulatoryQuality	0.389	0.422	-0.073	0.820	0.281	-1.336	-0.109	20.000	0.071	0.259
ResearchersinR&D	416.459	397.075	295.111	524.146	65.326	-0.830	-0.100	20.000	0.081	0.191
TRB	5.613	5.430	5.030	6.790	0.498	0.531	1.187	20.000	0.181	0.008

Source: Author's own results

Table 57 presents the mean, median, observed minimum, observed maximum, standard deviation, excess kurtosis, skewness, number of observations used, Cramér-von Mises test statistic, and p-value. The mean represents the average value of a dataset, serving as a measure of central tendency, while the median identifies the middle value and provides an alternative in the presence of outliers. The observed minimum and maximum values define the range of the data, marking the lowest and highest points. Standard deviation quantifies the spread of data points from the mean, with higher values indicating greater variability. Excess kurtosis signifies the fatness of the distribution's tails compared to a normal distribution, with positive values suggesting fatter tails, which are often undesirable. Skewness indicates asymmetry, with positive skewness indicating a distribution with a longer right tail and negative skewness suggesting a longer left tail. Positive skewness indicates a distribution with a tail stretching toward higher values, and negative skewness suggests a tail extending toward lower values. Skewness helps describe how the data deviates from a normal distribution and whether extreme values are clustered on one side. The number of observations used represents the total sample size in the analysis. The Cramér-von Mises test statistic evaluates the fit of the data to a hypothesized distribution, and its p-value assists in determining the statistical significance of any deviations from that distribution.

The descriptive statistics results for the quality of institutions show that only Government Effectiveness is statistically significant, with a p-value of 0.026 at the 95% confidence level. Other characteristics of Government Effectiveness show that it has a mean of 0.269, with a close median of 0.206. Other institutional quality indicators, such as Control of Corruption, Regulatory Quality, and Political Stability, were statistically insignificant.

Concerning the growth of the South African pharmaceutical sector, the Exported Growth (as a percentage of GDP) is highly statistically significant at all common significance levels (99%, 95%, and 90%) with a p-value of 0.000. The standard deviation of 36.467 and a strong positive skew of 2.496 indicate a few cases of extremely high growth. Similarly, the Exported Value of Pharmaceuticals is statistically significant at the 5% and 1% levels with a p-value of 0.002 and positive skewness of 0.879.

The FDI has a statistically significant p-value of 0.000, and the mean is 1.664, showing moderate inflows, but the variable is heavily skewed at 3.506, indicating few incidences of high FDI values. Similarly, the GNI per Capita reflects a statistically significant p-value of 0.001, a stable average income level across observations indicated by a mean of 5625.077. However, the slight negative skewness of -1.036 suggests that the income levels lean towards lower values.

The HDI is statistically significant at 95% confidence levels with a p-value of 0.024, has a mean of 0.683, and is slightly skewed at -0.216, indicating a slight deviation from a normal distribution. Regarding intra-industry trade, the MIIT is statistically significant at all common levels of confidence intervals with a p-value of 0.000. As expected, MIIT has a negative mean of -0.368 because intra-industry trade is generally low in the South African pharmaceutical sector. Lastly, the results for innovation indicators given by the Number of Patent Applications from residents and non-residents reveal that the number of patent applications by residents is significant, at a 95% confidence interval with a p-value of 0.012. On the one hand, the patent applications by residents also show a lower mean of 837.150 but an extreme skewness of 2.534, suggesting the presence of outliers. On the other hand, Non-resident applications are insignificant, with a p-value of 0.156, a high mean of 6506, and a positive skewness of 1.630, also suggesting the presence of outliers

The descriptive statistics results revealed diverse characteristics of variables regarding, *inter alia,* the p-value, the mean, and skewness. However, it is worth noting that although some

variables were statistically insignificant as per their Cramér-von Mises p-values, they were retained because they play a theoretically strong role in defining the latent construct, as evidenced by high factor loadings of 0.7 and above. Additionally, all variables were standardized to improve stability and maintain consistency across the analysis. The PLS Algorithm requires all variables to be standardized.

7.5.2 Reliability Test Results

Figure 21 below provides the reliability test results of the model used in the study. Composite Reliability (CR) Measures the internal consistency of a latent variable, while Average Variance Extracted (AVE) measures the amount of variance captured by a latent variable from its indicators. CR values above 0.7 indicate good reliability, while AVE above 0.5 indicates that the latent variable explains more than half the variance of its indicators.

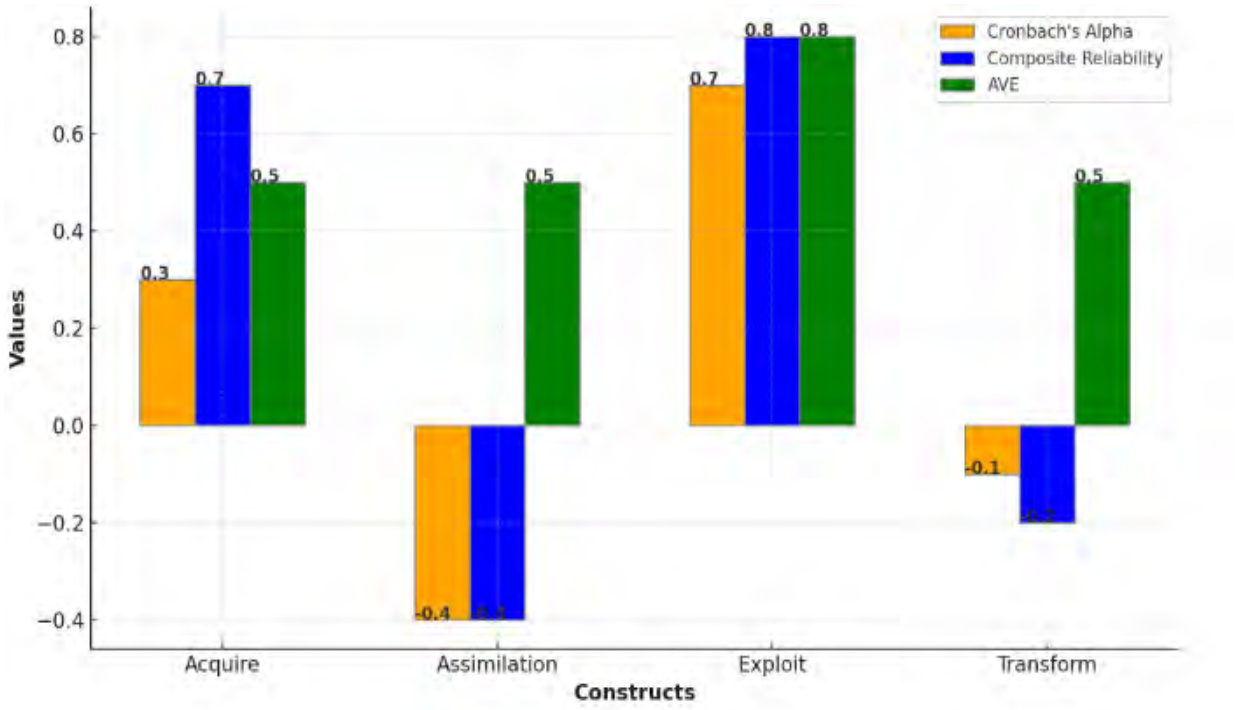

Figure 21: Cronbach's Alpha, Composite Reliability, and AVE for each Construct

Figure 21 shows that the construct explains more than 50% of the variance in the indicators because the AVE for all the constructs is 0.5, with Exploit registering the highest at 0.8. The composite reliability for Acquire and Exploit latent variables shows good reliability, while Assimilation and Transform have negative values. Similarly, the results for Cronbach's Alpha are low for all constructs except for Exploit, which shows a high reliability of 0.7. This means that the variables (i.e., No. patent applications by residents and non-residents) used to indicate the ability to exploit external knowledge are reliable and explain about 70% of the variance in

the latent construct. Although other reliability indicators were below accepted levels, the variables are usable given that all the latent constructs capture a minimum of 50% of their indicators, as reflected in the AVE results (Baharum *et al*., 2023).

7.5.3 Discriminant validity

The Fornell-Larcker Criterion assesses discriminant validity in structural equation modeling by ensuring that each construct in a model is distinct from the others. As highlighted in Chapter 7, the discriminant validity is confirmed when the square root of the AVE for a construct is greater than the correlations between that construct and other constructs in the model. Table 58 below shows the results of the Fornell-Larker Criterion for the model used in the study. The diagonal values represent the square root of the AVE for each construct, while the off-diagonal values show the correlations between the constructs.

Table 58 The discriminant validity results

	Acquire	Assimilation	Exploit	Growth'	MIIT	Transform
Acquire	0.690					
Assimilation	0.943	0.734				
Exploit	-0.158	-0.288	0.879			
Growth'	-0.680	-0.758	0.639	0.827		
MIIT	-0.234	-0.102	-0.200	0.028	1.000	
Transform	-0.374	-0.443	0.849	0.739	-0.079	0.697

Source: Author's own results

Table 58 above shows that the square root of the Acquire construct AVE is 0.690 is greater than its correlations with most other constructs, except Assimilation (0.943), which indicates a possible overlap between Acquire and Assimilation. Similarly, Assimilation's AVE square root is 0.734, which is greater than its correlations with constructs like Exploit (-0.288), Growth (-0.758), and Transform (-0.443), yet there is a strong correlation with the Acquisition construct. For the Exploitation construct, the AVE square root is 0.879, higher than its correlations with all other constructs. Similarly, Growth has an AVE square root of 0.827 is greater than its correlations with other constructs, suggesting good discriminant validity. The MIIT shows perfect discriminant validity with an AVE of 1.000 and low correlations with other constructs, confirming its uniqueness. Lastly, Transform's AVE square root is 0.697, with high correlations with Exploit (0.849) and Growth (0.739), suggesting a potential overlap. However, the presence of high correlations does not automatically invalidate the results if the constructs are reflective. In reflective models, indicators are manifestations of the same underlying

construct, meaning some degree of correlation is expected. If theoretical justification supports the relationship between Transform and Exploit, and collinearity issues are not present, the results can still be valid (Janadari *et al*., 2016). It is worth noting that good discriminant validity results for all constructs are desirable, however, correlation among constructs is expected in cases of reflective constructs where indicators reflect the latent variable. The PLS-SEM model can manage constructs' correlations well and is suitable for complex models with interrelated variables.

7.5.4 Inner Model Evaluation: Path Coefficients

This section presents the results of the Inner Model evaluation, which assesses the relationships between latent variables. Key metrics include Path Coefficients and R-squared (R^2). The path coefficients measure the strength and direction of the relationships between the constructs, helping to understand the dynamics at play. Values range from -1 to +1, with values closer to +1 or -1 indicating stronger relationships, whether positive or negative. Table 59 presents the path coefficients for the Inner Model.

Table 59: Path coefficients for Inner Model

	Path coefficients
Acquire -> Growth'	-0.036
Assimilation -> Growth'	-0.525
Exploit -> Growth'	0.225
MIIT -> Acquire	-0.234
MIIT -> Assimilation	-0.102
MIIT -> Exploit	-0.200
MIIT -> Transform	-0.079
Transform -> Growth'	0.302

Source: Author's own results

Table 59 above shows that exploitation and transformation are the only aspects of absorptive capacity that positively influence growth. For example, exploit has a moderate positive influence on growth, with a path coefficient of 0.225. Similarly, the transformation of external knowledge also plays a crucial role in driving growth, with a positive coefficient of 0.302. In contrast, Acquisition and Assimilation have a negative effect on growth, with a path coefficient of -0.036 and -0.525. Intra-industry trade shows a weak negative influence on all aspects of absorptive capacity. It is worth noting that the factor loadings are low; however, the inner model reflects the structural relationships between the latent constructs. The focus is not on the strength of the factor loadings but on the direction of the relationships between the latent

variables. Therefore, lower loadings in the inner model may still be acceptable if the inner relationships contribute meaningfully to the model's overall explanatory power (Hair *et al*., 2017).

The rationale behind the relationship between the absorptive capacity constructs and growth is that growth is measured using variables like export growth, revenue and sales growth, and profitability, among others. This means that growth can only be achieved if the acquired external knowledge has been successfully assimilated and transformed into a tradable product. Therefore, acquisition and assimilation can have a negative impact on growth if there are constraints like lack of efficiency, high costs, and misalignment of external knowledge with internal capacity. All these may lead to wasted efforts, which then contribute negatively to growth. These may be the underlying reasons for the results obtained. While acquisition and assimilation are essential for growth, they can impede long-term development without proper alignment with the firm's internal processes and culture (Todorova & Durisin, 2007). These results align with Xia and Roper (2016), who identified R&D Intensity, Employee Skills, and Continuous R&D as Potential Absorptive Capacity (PACAP) indicators, while the Number of Patents was identified as the Realised Absorptive Capacity indicators (RACAP).

The negative impact of intra-industry trade (measured by MIIT) on absorptive capacity is due to low intra-industry trade in the pharmaceutical sector, as has been determined in Chapter 5. Low intra-industry trade reduces opportunities for firms and industries to acquire, assimilate, and exploit new knowledge, essential for sustaining innovation and growth. As such, enhancing intra-industry trade is important in improving the absorptive capacity of firms and industries, especially in the pharmaceutical sector, where innovation is critical to competitiveness.

7.5.5 R^2 (R-Squared)

The R-squared shows the amount of variance in the dependent variable explained by the independent variables. R^2 values range from 0 to 1, with higher values indicating a better fit.

Table 60: R-squared values for the Inner Model

Variables	R-squared values
Acquire	0.058
Assimilation	0.11
Exploit	0.040
Growth	0.77
Transform	0.014
MIIT	1.00

Source: Author's own results

Table 60 presents the R-squared for absorptive capacity constructs (Acquire, Assimilation, Exploit, and Transform), marginal intra-industry trade (MIIT), and Growth. The results show a strong explanatory power for Growth and MIIT, as indicated by high R^2 values of 0.77 and 1.00. This means the model explains 77% of the variance in Growth and 100% in intra-industry trade. However, the model's ability to explain variance in the absorptive capacity constructs is weak, as indicated by the low R^2 values. Low R^2 values are common when working with complex, multidimensional constructs like absorptive capacity. In PLS-SEM, there are no strict thresholds for determining acceptable R^2 values. However, general guidelines indicate that R^2 values of 0.25, 0.50, and 0.75 represent weak, moderate, and substantial explanatory power, respectively (Hair *et al*., 2017).

7.5.6 Outer model evaluation

The outer model evaluation assesses how well the indicators reflect the latent variables. The key metrics include the outer loadings, which measure the correlation between an indicator and its latent variable. Values above 0.7 are generally acceptable; however, for exploratory research, values as low as 0.4 may be considered. The outer loading for this study's model is presented in Table 61 below.

Table 61: Outer loadings for the Outer model

	Acquire	Assimilation	Exploit	Transform	Growth'	ITT
Control of Corruption		0.868				
Exported growth in value for pharmaceutical products in SA					0.699	
Exported value of pharmaceuticals in SA					0.941	
FDI				1.000		
GNI per capita		-0.914				
GNI growth		0.616				
Government Effectiveness		0.925				
HDI		-0.977				
KL ratio				0.254		
MITT						1
Number Patent applications (Non – Residents)			0.912			
Number of Patent applications (Residents)			0.845			
Political Stability		0.425				
R&D%	0.700					
R&D value	-0.295					
Regulatory Quality		0.969				
Researchers in R&D	-0.742					
Rule of Law		0.21				
TRB	0.886					
Voice and Accountability		-0.204				

Source: Author's own results

Table 61 presents the factor loadings for the four dimensions of absorptive capacity, growth, and intra-industry trade in the South African Pharmaceutical sector. The first dimension is the acquisition, indicated by Researchers in R&D (-0.742), R&D% (0.700), R&D Value (0.295), and TRB (0.875). However, the R&D value was dropped in the model because the low factor loading of 0.295 was an unacceptable measure. This leaves Researchers in R&D (-0.742), R&D% (0.700), and TRB (0.875) as indicators of acquisition, as they show a strong relationship with the latent variable (Acquire).

The results show a counterintuitive, strong, positive correlation between trade barriers and acquisition. Contrary to these results, this study hypothesized in Chapter 4 that lower trade barriers allow firms to acquire external knowledge, which would have a positive impact on absorptive capacity. However, Todorova & Durisin (2007) argue that high trade barriers force firms to develop more robust strategies for acquiring external knowledge domestically or

within limited international frameworks. This means that whether high or low, trade barriers affect firms' absorptive capacity. The R&D has a significant and positive factor loading on the acquisition, contrasting with the strong negative factor loading of the number of researchers in R&D. This can be due to the different roles these two variables play in a firm's acquisition of external knowledge. The R&D reflects the portion of a firm's budget or resources allocated to research and development activities, which then reflects the level of commitment to innovation and acquiring external knowledge. Hence, positive and high factor loading on acquisition.

In contrast, the number of researchers in R&D may negatively impact acquisition for a number of reasons. First, if the R&D team prioritizes in-house innovation over sourcing external ideas, the firms focus on knowledge creation rather than external acquisition. This inward-looking approach can reduce the firm's flexibility and openness to external knowledge. Secondly, if the R&D workforce is large, it could introduce inefficiencies, including communication bottlenecks, bureaucratic inertia, or resistance to adopting external knowledge due to a "not invented here" mentality. Therefore, while R&D investment highlights a strategic orientation toward external knowledge acquisition, the internal dynamics associated with the R&D workforce can act as a constraint, which explains the divergent factor loadings (Cohen & Levinthal, 1989; Todorova & Durisin, 2007).

The second dimension is assimilation, which reflects the ability to internalize and process acquired knowledge. Out of the six indicators of institutional quality, three indicators showed high and positive factor loadings. Those are control of corruption (0.868), government effectiveness (0.925), and regulatory quality (0.969). Political stability (0.425) and the rule of law (0,21) showed a positive but insignificant relationship because their factor loadings were below 0.5. On the contrary, voice and accountability (-0,204) was the only governance indicator that showed an insignificant and negative factor loading. Other indicators include GNI per capita (-0.914), GNI Growth (0.616), and HDI (-0.977). The quality of institutions shows a strong positive correlation with assimilation, as evidenced by high factor loadings, except for Political Stability.

Surprisingly, the economic indicators such as GNI per capita and the HDI show strong negative correlations with assimilation, except GNI growth, which shows a moderate positive impact. These results were surprising, as one would expect that high levels of GNI and HDI would contribute positively to absorptive capacity because people who live high-quality lives should

easily understand and integrate new external knowledge into their domestic production processes, as highlighted in Chapter 4. However, the pharmaceutical industry requires innovation and highly specialised skills, which go beyond the ability to read, write, and access good health care that HDI measures. Therefore, the results imply that high life expectancy does not necessarily translate into a high level of innovation unless there are systematic measures put in place to promote education in the sciences and innovation that improve absorptive capacity. This is the area in which South Africa's education system has been lacking, hence the negative impact on knowledge assimilation. Furthermore, the GNI is used to indicate the market size, among other things; however, South Africa has the highest levels of wealth and income inequality in the world, as reflected by the Gini coefficients of 0.95 in 2017 and 0.63 in 2023 (African Development Bank, 2023, and Orthofer, 2017). This means that even if the GNI can be high, it could represent a small market concentrated in a few ends. In such cases, the high GNI may not contribute to a country's absorptive capacity.

The third dimension of absorptive capacity is transformation, which refers to converting acquired and assimilated knowledge into innovative products, services, or processes, indicated by FDI and the K/L ratio. The results show that transformation is strongly influenced by foreign FDI, as indicated by the highest factor loading of 1.00. In line with the study's *apriori e*xpectation, the findings suggest that FDI is critical in transforming knowledge into productive innovations, likely by introducing advanced technologies and capital into the country. However, the capital-labor (KL) ratio shows a weaker positive correlation (0.254), which still aligns with the expectations of the study even though the level of correlation is low.

The last dimension of absorptive capacity is exploitation, which reflects the ability of firms to apply assimilated knowledge for economic and innovative purposes. Exploitation is indicated by the number of patent applications, both from residents (0.845) and non-residents (0.912). Both indicators show a strong positive correlation with exploitation, implying that patents explain more than 80% of the variance in the exploitation aspect of absorptive capacity, making them a suitable indicator for exploitation. Furthermore, these factor loadings for non-resident applications reveal a significant contribution by non-residents in the South African economy in innovation.

The next variable is Growth, which reflects growth in the pharmaceutical sector linked to the impact of absorptive capacity. Growth is measured by the Exported growth in value for pharmaceutical products (0.699) and the Exported value of pharmaceuticals (0.914). The factor

loading for exported growth shows a moderate positive 0.699, while the factor loading for Exported value shows a strong positive correlation of 0.914. This also shows that exports explain more than 70 % of the variance in the growth of the sector.

Lastly, the factor loading for intra-industry trade represented by MIIT shows a perfect correlation of 1.00 because it is a direct measure of intra-industry trade. The factor loadings helped to identify the strong underpinning indicators for all dimensions of absorptive capacity in the South African pharmaceutical sector and to validate the proxies used to measure growth and intra-industry trade. As such, the determinants of absorptive capacity in the South African pharmaceutical sector from 2002 to 2021 can be illustrated as follows:

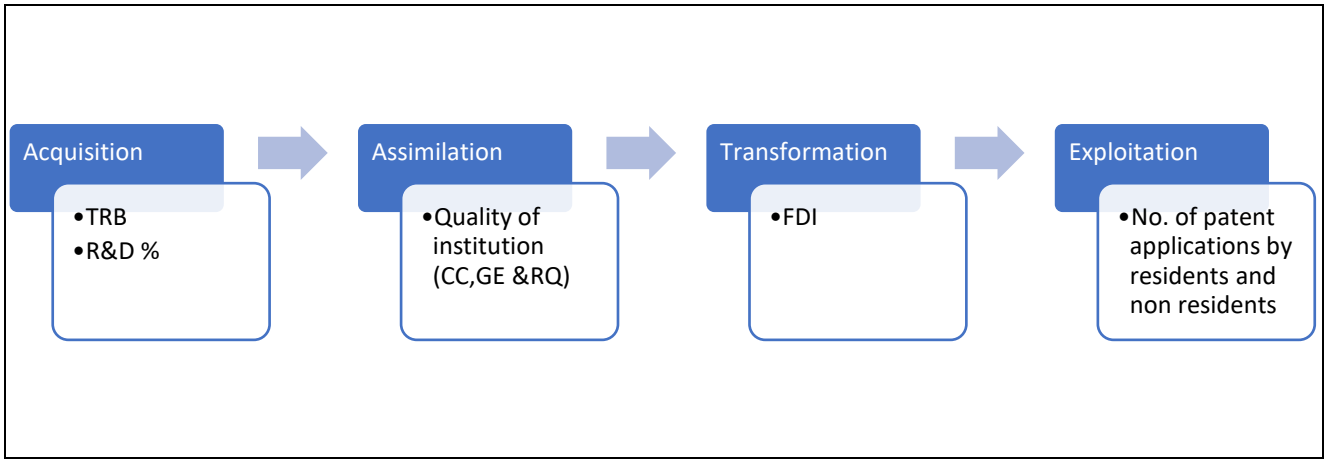

Figure 22: Determinants of Absorptive Capacity in the South African Pharmaceutical Sector
Source: Author's own construction
Note: CC – Control of Corruption
GE – Government Effectiveness
RQ – Regulatory Quality

Figure 22 above is a graphical presentation of the key determinants of absorptive capacity in the South African pharmaceutical sector, capturing all four dimensions and effectively addressing the third goal of this research. Based on the results, it can be deduced that the key determinants of absorptive capacity in the South African pharmaceutical sector are trade barriers (TRB), R&D%, the quality of institutions (indicated by control of corruption, government effectiveness, regulatory quality), FDI, and the number of patent applications.

7.6 The PLS-SEM Mediation Results

Having assessed how well the indicators reflect the latent variables. The study used the variables with acceptable factor loadings to further examine the relationship between absorptive capacity,

intra-industry trade, and growth in the pharmaceutical sector. The aim is to determine if there is any mediation effect among the variables based on objective four of the study.

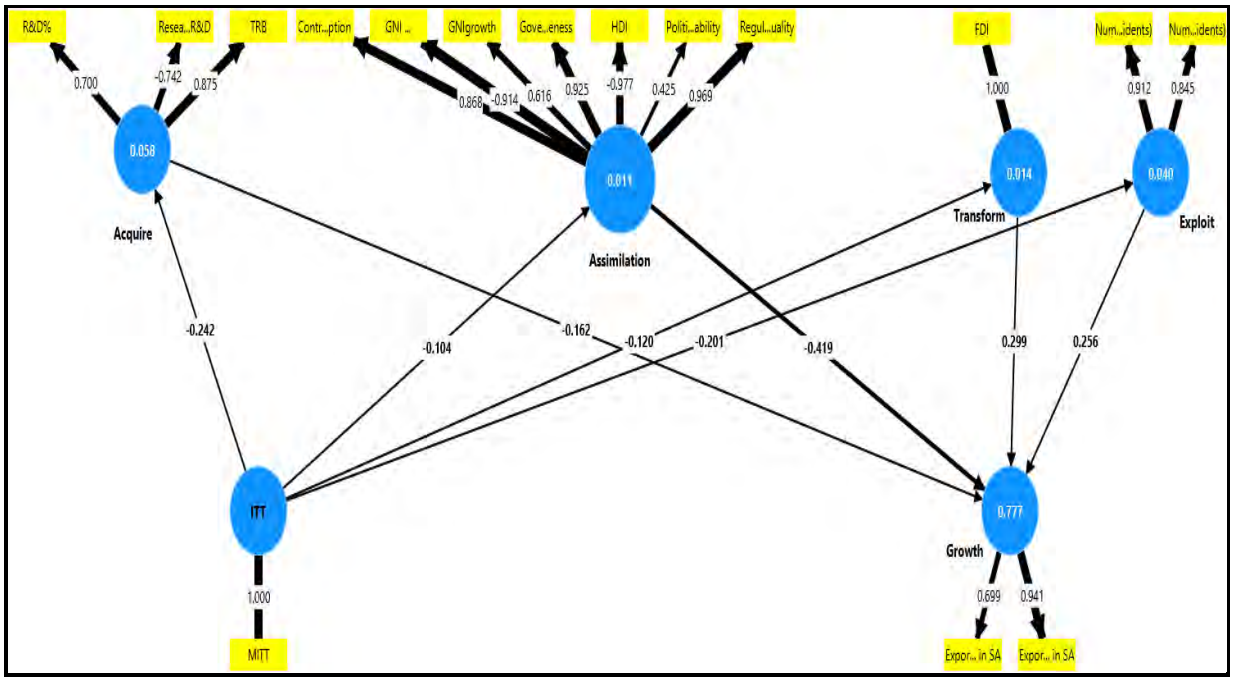

Figure 23: Inner and outer model loadings
Source: Author's own results

*NOTE: Bold arrows represent a strong correlation

The evaluation of the inner model has already shown the factor loadings between the constructs. However, Figure 23 presents a detailed view of the relationship between the three main variables: Absorptive capacity (represented by its four dimensions), intra-industry trade, and Growth. The results show that the intra-industry trade in the South African pharmaceutical sector has a weak and negative impact on all four aspects of absorptive capacity indicated by low factor loading of -0.242 on Acquire, -0.104 on Assimilation, -0.120 on Transform, and -0.419 on Exploit. As determined in Chapter 5, intra-industry trade is very low in the South African pharmaceutical sector, which limits the degree of technological overlap and restricts knowledge transfer in this industry (Vahter, 2010). Cohen & Levinthal (1989) also asserted that the foundational work on improving absorptive capacity depends on exposure to relevant knowledge and innovation, which intra-industry trade could facilitate. More importantly, Figure 23 reflects that the direction of the relationship is such that intra-industry trade affects absorptive capacity, and absorptive capacity then affects growth. Implying that the relationship between intra-industry trade and growth in the pharmaceutical sector is mediated by absorptive capacity. Therefore, the study rejects the null hypothesis, which states that "The impact of IIT

on the growth of the South African pharmaceutical sector is not mediated by Absorptive capacity."

7.7 Summary of Findings and Conclusion

This chapter explored the application of the PLS-SEM model starting from Confirmatory Factor Analysis to the mediation model. The study identified and confirmed the latent constructs through factor analysis to assess how well the hypothesized model represents the underlying data structure. This helped to determine the factors that positively affect absorptive capacity in the pharmaceutical sector, which are: Trade Barriers, R&D%, Control of Corruption, Government Effectiveness, Regulatory Quality, FDI, and the Number of patent applications. The SEM mediation analysis, in turn, highlighted the direction of the relationships among variables.

The discussion proceeded to present the PLS-SEM results which indicated that the low intra-industry trade within the pharmaceutical sector negatively affects absorptive capacity, contributing to low growth. Consequently, the relationship between intra-industry trade and growth in the South African pharmaceutical sector is mediated by absorptive capacity. By enhancing the identified determinants of absorptive capacity and intra-industry trade, South Africa can improve its absorptive capacity, which may lead to sustainable industry growth. These findings provide valuable insights for policymakers seeking to reduce dependence on developed countries for pharmaceutical supplies.

CHAPTER 8
Policy recommendation and conclusion

8.1 Introduction

Following the study's research findings presented in the previous three chapters, this chapter draws a set of conclusions based on the consolidated findings and also presents policy recommendations. The chapter commences with a review of the primary research objectives and justification of the study, followed by the consolidated research findings. It then discusses the policy implications of the research and the study's contribution to the literature. This chapter proceeds to present the limitations of the study and, lastly, the recommendations for future research.

8.2 Summary of the research objectives

The study's overarching goal was to measure the relationship between absorptive capacity and growth influenced by intra-industry trade in the South African pharmaceutical sector. This goal was broken down into four objectives to capture nuances associated with absorptive capacity, intra-industry trade, and growth. The first subgoal aimed to measure intra-industry trade in the South African pharmaceutical sector and identify a key factor to improving it. This involved examining the extent to which new imports are matched by new exports. Higher matching levels signaled high intra-industry trade, while low matching levels signaled the opposite. The method used in the analysis also indicated specialisation in or out of the industry. Subsequently, the study identified productivity as a key determinant of intra-industry trade in the pharmaceutical sector and investigated factors that influence it, as understanding those factors is essential for enhancing intra-industry trade.

Considering that intra-industry trade thrives in areas where the country has a comparative advantage, the second objective was to determine the comparative advantage in the South African pharmaceutical sector. This was achieved by comparing South Africa's comparative advantage to 17 selected trading partners. Out of the 17 countries, six were African, three were non-African emerging countries, and eight were developed countries. The selection was based on the size of pharmaceutical manufacturing and trade relations with South Africa. Here, the focus was on (i) identifying product groups in which South Africa has a comparative advantage in producing compared to the trading partners, (ii) comparing commodity groups within the country to see which pharmaceutical product is produced more efficiently than the others, and

(iii) conducting a time-series analysis to examine the comparative advantage of a country has evolved over time. Within this objective, the study also measured the pharmaceutical trade complementarity between South Africa and the selected African and emerging countries. This highlighted potential opportunities for developing countries like South Africa to increase their exports of pharmaceuticals and eventually improve their comparative advantage. Most importantly, it revealed pharmaceutical trade complementarities among African countries.

The third objective was to identify the determinants of absorptive capacity in the South African pharmaceutical sector so as to intentionally invest in those factors that may enhance the ability to absorb and adapt external knowledge. The fourth objective was to examine the relationship between intra-industry trade and absorptive capacity, focusing on how intra-trade influences absorptive capacity in the pharmaceutical sector. Lastly, the fifth objective examined the relationship between absorptive capacity, intra-industry trade, and South African pharmaceutical industry growth. Examining this interplay aims to improve the understanding of how knowledge transfer through trade can be effectively absorbed to support the sector's growth and eventually reduce reliance on imported medicines.

8.3 Recapping the motivation of the study

The motivation for this study is based on the observation that South Africa has a well-developed pharmaceutical sector and is the only country in the SADC region that meets the World Health Organization's good manufacturing practice standards (DTI, 2020). However, the local manufacturers rely heavily on API imports, and pharmaceutical exports have been significantly low for the past 20 years, suggesting that South Africa depends on foreign countries for pharmaceuticals and that the trade imbalance is to South Africa's detriment. Moreover, there are a few countries, particularly China and India, that dominate the global pharmaceutical supply, accounting for a combined 31% of registered Food and Drug Administration (FDA) products, which poses a significant risk (American Affairs, 2024).

The primary concern is that the pharmaceutical sector not only generates welfare and promotes growth through technological advancements but also provides essential medicines crucial for public health (Granville, 2003). Reliance on imports makes consumers vulnerable to external shocks like COVID-19, a pandemic that demonstrated how global crises can disrupt supply chains, resulting in shortages of critical products. This crisis environment can also empower firms with market dominance to increase prices, making essential medicines unaffordable,

particularly in developing countries compared to their developed counterparts (Boshoff, 2020). Furthermore, depending on pharmaceutical imports is even riskier during unpredictable political regimes and increasing economic nationalism in influential global trading partners like the USA. For example, South Africa finds itself in a particularly challenging situation as it navigates the complexities of its trading and political alliance, BRICS, in its efforts to de-dollarize while simultaneously facing sudden increases in trade tariffs from the United States. This political shift increases the urgency for self-reliance and the need for intensified intra-African trade, especially within a critical sector that directly impacts population health.

8.4 Reiterating the justification of the study

Absorptive capacity is a well-researched concept in business research, yet there are few empirical studies in International Economics examining its relationship with trade in African countries. Previous research has primarily focused on absorptive capacity's links to FDI and economic growth but not on the pharmaceutical sector, which often centres on developed countries or India and China. This study expands empirical literature by examining intra-industry trade and absorptive capacity in a developing country, an area that has largely been neglected. Furthermore, the study contributes to the methodology by measuring intra-industry trade as a fundamental driver of absorptive capacity, an approach that moves beyond the traditional focus on FDI as the main external knowledge source. Most studies have focused on only measuring the relationship between absorptive capacity and FDI, and are not specific to the pharmaceutical sector. Additionally, the study develops a more comprehensive quantitative measure of absorptive capacity, integrating all four dimensions, incorporating acquisition, assimilation, transformation, and exploitation, which previous empirical studies have failed to achieve.

The findings of this research aim to guide policymakers, industry stakeholders, and development agencies in their efforts to promote innovation, optimize resource allocation, and enhance the competitiveness and sustainability of the South African pharmaceutical sector. Ultimately, this study contributes to broader initiatives aimed at promoting inclusive industrial development, mitigating vulnerabilities in the health sector, and advancing regional pharmaceutical integration in Southern Africa. Given the COVID-19 pandemic's implications, this study is crucial for improving South Africa's global competitiveness and pharmaceutical self-sufficiency, benefiting the broader Southern African region.

8.5 Consolidation of research results and their implications

Chapter 5 addressed the first objective of this study by using Marginal Intra-Industry Trade (MIIT) and Unmatched Changes in Trade (UMCIT) to measure intra-industry trade and subsequently measured productivity using the Data Envelope. The MIIT and UMCIT results showed that new trade is inter-industry, and specialisation is often out of the industry, aligning with existing literature in that intra-industry trade is more prevalent in developed than developing countries. However, while trade was found to be largely inter-industry, there were significant intra-industry changes in 2008, 2010, and 2011 and periods of industry specialisation in 2002, 2013, 2014, 2016, and 2019. As highlighted in the results section, these two findings revealed three major implications for the South African pharmaceutical industry.

The first implication is that low intra-industry trade and limited specialisation in South Africa will result in factors of production flowing out of the pharmaceutical industry, as theory suggests that resources flow to segments of the economy where there is specialisation. The second implication relates to adjustment costs because when trade expansion is inter-industry, the movement of resources is costly and may result in the industry not being flexible enough to swiftly respond to external shocks. This was evident in South Africa and many other African countries that depended on foreign countries for personal protective equipment (PPE) and vaccines during the height of COVID-19. Lastly, periods of significant intra-industry changes and those of specialisation in the industry imply some level of competitiveness, which, if reinforced, would put the South African pharmaceutical industry in a better trade position than it is now.

Chapter 5 went further by measuring productivity in the pharmaceutical sector in an attempt to determine the key factor that would contribute to increasing exports in order to match imports. The DEA results showed that technological changes strongly influence the Total Factor Productivity. These findings imply that policymakers must create an enabling environment for stimulating technological advancement by promoting technology transfer and adoption, providing incentives for R&D activities, and promoting collaboration between academia, industry, and government. In line with the National Development Plan, Vision 2030, which aims to improve the link between innovation and business requirements, collaborating with academia will also help align education and training with the skill set needed in the pharmaceutical industry to achieve more productivity. This would put the sector in a better position to produce internationally competitive pharmaceutical products. Moreover, for a

country to enhance its intra-industry trade, it is important to know the products with a comparative advantage.

Accordingly, Chapter 6 addressed the second objective by measuring the comparative advantage and trade complementarity in the pharmaceutical sector of South Africa. As expected, South Africa and some other African countries have no comparative advantage in certain HS product lines despite having relatively developed pharmaceutical industries. Furthermore, the finding that emerging countries are generally lagging behind developed countries in comparative advantage is consistent with the study by Mahajan *et al*. (2015) as discussed in section 6.3 of Chapter 6. However, this study went further than Mahajan *et al*. (2015) by doing a cross-country comparison and found that some African countries have a comparative advantage over emerging and developed countries in producing certain products. The results of the TCI showed high complementarity between the export and import profiles of South Africa and the selected African and emerging partners. This highlights the opportunities for South Africa to increase exports of pharmaceuticals and eventually improve their comparative advantage.

Moreover, Chapter 6 revealed four critical issues: (i) Some African countries (Egypt, Tunisia, Morocco, and Nigeria) have a comparative advantage in producing certain pharmaceutical products. (ii) There is complementarity between South Africa and African countries where pharmaceutical exports match the pharmaceutical imports of another country and vice versa. Therefore, there is scope for more intense intra-African pharmaceutical trade. (iii) South Africa showed a comparative disadvantage only in HS3004, and the rest were comparative-advantage neutral. This implies that the comparative advantage could improve if appropriate strategies are implemented to enhance production. (iv) Globally dominant pharmaceutical producers also have areas of weak comparative advantage and even a comparative disadvantage in some cases, despite their global standing. This suggests South Africa and other African countries can exploit these weaknesses to strengthen their pharmaceutical exports. Therefore, with strategic trade agreements, African countries can penetrate foreign markets and recalibrate their global participation in pharmaceutical trade. If the law of comparative advantage is anything to go by, South Africa and its trading partners would benefit from producing and exporting pharmaceuticals that can be produced at a lower cost, thus taking advantage of economies of scale. Improving a comparative advantage in the production of pharmaceuticals requires a combination of strategic, economic, and regulatory measures.

Chapter 7 employed the SEM to address the last three objectives of the study, which were to identify the determinants of absorptive capacity, establish the relationship between intra-industry trade and Absorptive Capacity, and determine the effect of absorptive capacity and intra-industry trade on the growth of the South African pharmaceutical sector. The results showed that absorptive capacity in the South African pharmaceutical sector is determined by R&D% and TRB to acquire, the quality of institutions to assimilate, FDI to transform, and the number of patent applications to exploit external knowledge. Control of corruption, government effectiveness, and regulatory quality are the only governance aspects that have positively affected absorptive capacity in the two decades from 2002-2021. The findings also showed that the low level of intra-industry trade negatively affects absorptive capacity, ultimately limiting industry growth. This implies an indirect relationship between intra-industry trade and growth, mediated by absorptive capacity.

8.6 Contribution to the body of knowledge

This study adopted a multifaceted approach to empirically investigate local and external factors affecting production and trade within the South African pharmaceutical industry. As such, three important contributions to literature can be highlighted. Firstly, while traditional theories have long supported the notion that international trade contributes to economic growth, this research presents a more nuanced perspective. The findings showed that the growth experienced by the South African pharmaceutical sector is significantly influenced by its ability to effectively assimilate and utilize external knowledge. This capacity to absorb innovative ideas and practices is essential for maximizing the benefits of trade and, consequently, for driving growth. Thus, the impact of international trade on growth is indirect, mediated by absorptive capacity. For industries to fully harness the advantages of intra-industry trade, they must enhance their absorptive capacity. This connection has not been explicitly made in international trade literature.

Secondly, the study quantitatively assessed absorptive capacity within the South African pharmaceutical sector, encompassing all four dimensions. The method showed the impact of each variable on specific dimensions of absorptive capacity. For instance, while previous research, such as that of Hurtado & González-Campo (2015), considered institutional cooperation as a factor influencing the Assimilation dimension, this study further disaggregated the institutional quality indicators to clearly identify which specific factors enhance an industry's capacity to assimilate external knowledge. The findings showed that Control of

Corruption, Government Effectiveness, and Regulatory Quality are critical governance aspects for knowledge assimilation.

Thirdly, the study reaffirmed the essential role of Research and Development in a country's capability to acquire external knowledge, aligning with the work of scholars like Harris & Yan (2019), Xia & Roper (2016), and Hurtado & González-Campo (2015). Notably, many studies have overlooked the impact of trade barriers on acquiring new knowledge. The results from the confirmatory factor analysis indicate that, alongside R&D investment, trade barriers significantly influence the ability to acquire new knowledge.

Moreover, evaluating the level of intra-industry trade within the South African pharmaceutical sector and identifying areas of comparative advantage offer critical insights into the competitiveness of the sector. These insights are essential for advancing programs like the Pharmaceutical Manufacturing Plan for Africa and the African Continental Free Trade Area, which aim to enhance intra-African trade in the pharmaceutical industry.

8.7 Conclusion

Despite its high import demand, the South African pharmaceutical sector is vital in supplying pharmaceuticals in Southern Africa. It serves as a launching site for firms to access other African pharmaceutical markets. This study identified intra-industry trade as a vehicle for promoting innovation and competitiveness in the pharmaceutical sector. As such, the Marginal Intra-Industry Trade Index was used to determine the type of new trade that is taking place, while Normalised Revealed Comparative Advantage was used to identify comparative advantage in pharmaceutical products. Determining the type of trade and comparative advantage helps to understand how the country integrates into the global pharmaceutical value chain, which then informs the segments of production that need to be strengthened to increase output and global presence. The study also showed that improvement in productivity correlates with increased specialisation and significant intra-industry changes in the pharmaceutical sector of South Africa. As firms become more specialized, they tend to focus on their key strengths, adopt advanced technologies, and streamline production processes, all of which contribute to improved efficiency and output.

The study identified the determinants of absorptive capacity and its role in mediating the relationship between intra-industry trade and industry growth in the South African pharmaceutical sector using the PLS-SEM. This analysis also showed a breakdown of how each

determinant contributes to specific dimensions of absorptive capacity (acquisition, assimilation, transformation, and exploitation). Understanding the determinants of absorptive capacity is essential for targeted interventions aimed at strengthening production capabilities and intensifying intra-industry trade critical for growth, self-reliance, and specialisation within the pharmaceutical sector. For instance, the study showed that while knowledge acquisition and assimilation form part of absorptive capacity, they will only contribute to growth if the external knowledge is strategically aligned with local innovation efforts and successfully exploited into patented products. To achieve this, the sector requires strong government support in regulatory quality, governance, and infrastructure development.

Furthermore, the study highlighted that some of the factors that contribute to high pharmaceutical imports in South Africa are industry-specific, while some are national issues that can only be combated if the government collaborates with private producers. South Africa is currently battling with infrastructure deterioration, causing an additional strain on firms in South Africa across the sectors, resulting in reduced comparative advantage. Infrastructure problems like water shortages and power cuts make it even more difficult for local products to compete globally, as these problems add to the cost of production. The South African government should urgently solve the infrastructure problems to create an enabling environment for promoting local production. Producers, on the other hand, need to take advantage of the existing opportunity of manufacturing generic medicines and APIs, which are in high demand in South Africa and many other African countries but are mainly supplied by India and China.

Additionally, the shared objective of the PMPA and the African Continental Free Trade Area (AfCFTA) of improving access to medicines and healthcare products across the African continent provides an opportunity for South Africa to establish and uphold a connection between trade and health within the continent. The trade facilitation provided by the AfCFTA's elimination of trade barriers has the potential for a larger market for pharmaceuticals produced under the PMPA, which can lead to increased exports of medicines originating from South Africa. Active engagement with PMPA and AfCFTA can help to achieve affordable medicines and improve healthcare access for South Africans and other African citizens. Hopefully, the commitment by the African Development Bank to establish the African Pharmaceutical Technology Foundation is a step in the right direction. Most importantly, South Africa needs a concerted and sustainable pharmaceutical sector innovation system to avoid episodic

improvements in intra-industry trade and TFP changes. So far, significant improvements are induced by major crises like HIV/AIDS and COVID-19. The recent tariff increase imposed by the United States government on many countries, including South Africa, is a testament that African countries need to be more intentional about deepening intra-African trade, especially in pharmaceuticals.

8.8 Limitations of the study

Although this study has reported essential and interesting findings that contribute to knowledge, it is crucial to note some limitations. First, the study is focused on the pharmaceutical sector of South Africa, but most variables used were national-level because of constraints in the availability of industry-specific data. However, as evident in Table 5 in Chapter 3, most empirical work in absorptive advantage resorted to national-level data for similar reasons. Secondly, it is worth acknowledging that while this study used a purely quantitative approach, some aspects of absorptive capacity would be better captured through qualitative means. Notwithstanding this fact, the study is of the view that any activity that improves the absorptive capacity of the industry should translate into quantifiable output, hence the quantitative approach.

8.9 Recommendation for future research

This study provided significant insights into the relationship between absorptive capacity, intra-industry trade, and growth in the South African pharmaceutical sector. However, several areas require further investigation to build upon these findings. Given the limitations of the study and the dynamic nature of global pharmaceutical trade, future research should aim to deepen understanding of key areas that can contribute to enhancing South Africa's pharmaceutical competitiveness, promoting intra-industry trade, and improving absorptive capacity for sustainable growth**.** Future research should focus on expanding intra-industry trade analysis, identifying product-specific competitive advantages, assessing the role of innovation and technology in absorptive capacity, and exploring specific institutional and policy reforms that could further strengthen pharmaceutical trade and production.

Considering that the study found trade in the South African pharmaceutical sector to be largely inter-industry, with limited intra-industry trade, future studies should examine the barriers preventing intra-industry trade growth in the pharmaceutical sector, focusing on regulatory constraints, pricing structures, and supply chain inefficiencies. Regarding the examination of

comparative advantage, a detailed product-level analysis would be beneficial in identifying specific pharmaceutical products where South Africa can develop and sustain a comparative advantage. Since the study confirmed that some African countries have competitive strengths in certain pharmaceutical products, further research could quantify trade complementarities in more detail and evaluate how strategic trade partnerships or regional agreements could accelerate intra-African pharmaceutical trade.

Furthermore, the study found technological advancements to strongly influence Total Factor Productivity in the pharmaceutical sector; future research assessing which specific innovations (for example, Artificial Intelligence-driven drug discovery, biotechnology, or local API production) could enhance absorptive capacity and improve competitiveness would necessary. A comparative study with successful pharmaceutical hubs like India and China could offer valuable insights into best practices for promoting innovation in pharmaceutical production. Like technology, institutional reforms are crucial in enhancing absorptive capacity, as this study found that Control of Corruption, Government Effectiveness, and Regulatory Quality plays a significant role in knowledge assimilation. Future research should explore how targeted governance reforms, trade policy adjustments, and financial incentives (e.g., tax breaks for R&D, funding for technology adoption, and trade facilitation measures) can create a more enabling environment for pharmaceutical sector growth.

Another critical area for future research involves local API production, as the reliance on imported active pharmaceutical ingredients exposes the industry to global supply chain disruptions. Further studies are necessary to assess the feasibility of API production in South Africa, the necessary policy and investment requirements, and the economic implications of reducing API import dependence. Lastly, while this study employed a quantitative methodology, future research could incorporate qualitative approaches, such as case studies, expert interviews, and industry surveys, to gain deeper insights into how firms perceive and implement absorptive capacity strategies. By addressing these research gaps, future studies can contribute to a more comprehensive understanding of how absorptive capacity, intra-industry trade, and institutional support can drive sustainable growth in South Africa's pharmaceutical sector**.**

List of references

African Development Bank. (2023). South African economic outlook: Income inequality and Gini coefficient. Available at https://www.afdb.org/en/countries/southern-africa/south-africa/south-africa-economic-outlook.

African Pharmaceutical Analysis Report (2021). Available at https://www.insights10.com/report/africa-pharmaceutical-market-analysis/. Accessed on 03/ 04/2024.

African Union Commission and the United Nations Industrial Development Organization (2012). Pharmaceutical Manufacturing Plan for Africa: Business Plan. *1*, 1–119. https://www.nepad.org/publication/pharmaceutical-manufacturing-plan-africa

Ahmed, S. S., Guozhu, J., & Khan, M. M. (2024). Examining intellectual capital and knowledge absorptive capacity for high innovative performance. *Knowledge and Process Management*, *31*(2), 128-139.

Ahuja, G., & Katila, R. (2001). Technological acquisitions and the innovation performance of acquiring firms: A longitudinal study. *Strategic Management Journal*, *22*(3), 197-220.

Aitken, B., Gordon, H. & Harrison, A.E., 1997, 'Spillovers, foreign investment, and export behavior', *Journal of International Economics* 43(1–2), 103–132. https:// doi.org/10.1016/S0022-1996(96)01464-X

Ajayi, S. 1. (2006). FDI and Economic Development in Africa. *The OAU After Twenty Years*, *19*(2), 63–78. https://doi.org/10.4324/9780429313264-4

Akunne, O. O., Valoyi, V., Wehmeyer, A., Johnson, Y., & Coetzee, R. (2023). Implications of the South African National Drug Policy on prescribing patterns: a case study of the Limpopo province. *Journal of Pharmaceutical Policy and Practice*, *16*(1), 111.

Alesina, Alberto, Sule Özler, Nouriel Roubini, & Phillip Swagel. (1996). Political instability and economic growth. *Journal of Economic growth* 1 (1996): 189-211.

Aliasghar, O., Rose, E. L., & Chetty, S. (2019). Building absorptive capacity through firm openness in the context of a less-open country. *Industrial Marketing Management*, *83*, 81-93.

Al-Mawali, N. (2005). Bilateral intra-industry trade flows and intellectual property rights protection: first empirical evidence. *Applied Economics Letters*, *12*(13), 823-828.

American Affairs. (2024). Foreign government subsidies and FDA regulatory failures are causing drug shortages in the United States: Here's how to fix it. *American Affairs Journal*. Available at: https://americanaffairsjournal.org/2024/02/foreign-government-subsidies-and-fda-regulatory-failures-are-causing-drug-shortages-in-the-united-states-heres-how-to-fix-it/.

Arrow, K., Bolin, B., Costanza, R., Dasgupta, P., Folke, C., Holling, C. S., & Pimentel, D. (1995). Economic growth, carrying capacity, and the environment. *Ecological economics*, *15*(2), 91–95.

Aspen Holdings (2023). Healthcare. We care. *Integrated Report*. Available at https://www.aspenpharma.com/wp-content/uploads/2023/10/Aspen-2023-Integrated-Report.pdf. Accessed on 31/03/2025.

Atlantic Council. (2022). *Attracting foreign direct investments*. https://www.atlanticcouncil.org/in-depth-research-reports/report/attracting-foreign-direct-investments/

African Union Commission (AUC). (2015). *Agenda 2063: The Africa We Want (Final Edition)*. African Union Commission. https://au.int/en/agenda 2063

African Union Commission and the United Nations Industrial Development Organization, (2012). Pharmaceutical Manufacturing Plan for Africa: Business Plan. *1*, 1–119. https://www.nepad.org/publication/pharmaceutical-manufacturing-plan-africa

Awwad, M. S., Abuhommous, A. A., & Adaileh, A. M. (2025). Unravelling the relationship between absorptive capacity, innovation, and financial performance: A longitudinal study. International Journal of Innovation Studies, 9(2). https://doi.org/10.1016/j.ijis.2025.02.001

Baharum, H., Ismail, A., Awang, Z., McKenna, L., Ibrahim, R., Mohamed, Z., & Hassan, N. H. (2023). The study adapted instruments based on Confirmatory Factor Analysis (CFA) to validate measurement models of latent constructs. *International Journal of Environmental Research and Public Health*, *20*(4), 2860.

Balle, A. R., Oliveira, M., & Curado, C. M. M. (2020). Knowledge sharing and absorptive capacity: interdependency and complementarity. *Journal of Knowledge Management*, *24*(8), 1943-1964.

Balassa, B. (1978). Exports and economic growth: further evidence. *Journal of development Economics*, *5*(2), 181-189.

Balassa, B. (1966). Tariff reductions and trade in manufacturers among the industrial countries. *The American Economic Review*, *56*(3), 466-473.

Balk, B.M., 2013, *Industrial price, quantity, and productivity indices: The micro-economic theory and an application*, Springer Science & Business Media. New York..

Bangalee, V., & Suleman, F. (2019). Pseudo-generics in South Africa: a price comparison. *Value in health regional issues*, *19*, 87–91.

Batra, Amita, and Zeba Khan.2005. *Revealed comparative advantage: An analysis for India and China*. No. 168. Working paper.

Becker, S. O., Egger, P. H., & Von Ehrlich, M. (2013). Absorptive capacity and the growth and investment effects of regional transfers: A regression discontinuity design with heterogeneous treatment effects. *American Economic Journal: Economic Policy*, *5*(4), 29-77.

Belderbos, R., Carree, M., Diederen, B., Lokshin, B., & Veugelers, R. (2004). Heterogeneity in R&D cooperation strategies. *International journal of industrial organization*, *22*(8-9), 1237-1263.

Benguria, F., Matsumoto, H., & Saffie, F. (2022). Productivity and trade dynamics in sudden stops. *Journal of International Economics*, *139*, 103631.

Bernard, A.B. & Jensen, J.B., 2004, 'Exporting and productivity in the USA', *Oxford Review of Economic Policy* 20(3), 343–357. https://doi.org/10.1093/oxrep/grh020

Bernhofen, D. M., & Brown, J. C. (2004). A direct test of the theory of comparative advantage: the case of Japan. *Journal of Political Economy*, *112*(1), 48-67.

Blanco, L. R., Gu, J., & Prieger, J. E. (2016). The impact of research and development on economic growth and productivity in the US States. *Southern Economic Journal*, *82*(3), 914-934.

Blomström, M., & Kokko, A. (1998). Multinational corporations and spillovers. *Journal of Economic surveys*, *12*(3), 247-277.

Boldrin, M., & Levine, D. K. (2013). The case against patents. *Journal of Economic Perspectives*, *27*(1), 3-22.

Borensztein, E., De Gregorio, J., & Lee, J. W. (1998). How does foreign direct investment affect economic growth?. *Journal of international Economics*, *45*(1), 115-135.

Bosch, F. A. V. D., Volberda, H. W., & Boer, M. D. (1999). Coevolution of firm absorptive capacity and knowledge environment: organizational forms and combinative capabilities. *Organization Science*, *10*(5), 551-568.

Boshoff, W. H. (2020) 'South African competition policy on excessive pricing and its relation to price gouging during the COVID-19 disaster period', *South African Journal of Economics*, 0(i), pp. 1–29. doi: 10.1111/saje.12268.

Bowen, Harry P. (1983). On the theoretical interpretation of indices of trade intensity and revealed comparative advantage. *Weltwirtschaftliches Archiv* 119, no.3: 464-472.

Boynton, A. C., Zmud, R. W., & Jacobs, G. C. (1994). The influence of IT management practice on IT use in large organizations. *MIS quarterly*, 299–318.

Brown, T. A. (2006). *Confirmatory factor analysis for applied research*. Guilford Press.

Brülhart, M. (2008). An account of inter-industry trade, 1962-2006. *Research paper series in Globalisation, Productivity, and Technology*, *8*.

Brülhart, M. (1994). Marginal intra-industry trade: measurement and relevance for the pattern of industrial adjustment. *Weltwirtschaftliches Archiv*, (H. 3), 600-613.

Cattaneo, N., & Fryer, D. (2003). Intra-versus inter-industry specialisation, labour market adjustment and poverty: implications for regional integration in Southern Africa.

Carvalho, J. R. M., Amorim, W. V. T., & Araújo, E. K. M. (2022). Organizational Performance of a Public Higher Education Institution: An Analysis from the Perspective of Absorptive Capacity and Innovation. *International Journal of Business and Management*, *17*(12).

Camisón, C., & Forés, B. (2010). Knowledge absorptive capacity: New insights for its conceptualization and measurement. *Journal of Business Research*, *63*(7), 707-715.

Castellani, D., & Zanfei, A. (2003). Technology gaps, absorptive capacity and the impact of inward investments on productivity of European firms. *Economics of Innovation and New Technology*, *12*(6), 555-576.

Ceccagnoli, M., Graham, S. J., Higgins, M. J., & Lee, J. (2010). Productivity and the role of complementary assets in firms' demand for technology innovations. *Industrial and*

corporate change, *19*(3), 839-869.

Cipla Medpro South Africa (2022). Cipla Deal to ensure affordable access to biosimilars. Available at https://www.cipla.co.za/press-releases/cipla-deal-to-ensure-affordable-access-to-biosimilars.

Ciuriak, D., Lapham, B. J., Wolfe, R., Collins-Williams, T., & Curtis, J. M. (2011). Firms in international trade: Towards a new-new trade policy. *Social Science Research Network, Rochester, NY*.

Clerides, S. K., Lach, S., & Tybout, J. R. (1998). Is learning by exporting important? Micro-dynamic evidence from Colombia, Mexico, and Morocco. *The quarterly journal of economics*, *113*(3), 903-947.

Chen, T. J., & Tang, D. P. (1990). Export performance and productivity growth: The case of Taiwan. *Economic Development and Cultural Change*, *38*(3), 577-585.

Cockburn, I. M., & Henderson, R. M. (1998). Absorptive capacity, coauthoring behavior, and the organization of research in drug discovery. *The journal of industrial economics*, *46*(2), 157–182.

Coelli, T.J., Rao, D.S.P., O'donnell, C.J. & Battese, G.E., 2005, *An introduction to efficiency and productivity analysis*, Springer Science & Business Media. New York.

Cohen, W. M. and Levinthal, D. A. (1989) 'Absorptive Capacity: A New Perspective on Learning and Innovation', *Administrative Science Quarterly*. doi: 10.2307/2393553.

Costinot, A., & Donaldson, D. (2012). Ricardo's theory of comparative advantage: old idea, new evidence. *American Economic Review*, *102*(3), 453-458.

Council on Health Research for Development (COHRED) & New Partnership for Africa's Development (NEPAD). (2010). *Strengthening pharmaceutical innovation in Africa*. https://www.policycures.org/wp-content/uploads/2022/11/COHRED-NEPAD_Strengthening_Pharmaceutical_Innovation_AfricaREPORT.pdf

Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.

Cruz T. (2024). The Impact of Patent Expirations on the Pharmaceutical Industry. *Journal of Chemica and Pharmaceutical Research.* doi:10.37532/0975-7384.2024.16(5).150.

Cuervo-Cazurra, A., & Rui, H. (2017). Barriers to absorptive capacity in emerging market firms. *Journal of World Business*, *52*(6), 727-742.

Dalum, B., Laursen, K., & Villumsen, G. (1998). Structural change in OECD export specialisation patterns: De-specialisation and 'stickiness'. *International Review of Applied Economics, 12*(3), 423–443. https://doi.org/10.1080/0269217980000001

Dahlander, L., & Gann, D. M. (2010). How open is innovation?. *Research policy*, *39*(6), 699-709.

Damijan, P. J., & Kostevc, C. (2007). Learning-by-exporting: Continuous productivity improvements or capacity utilization effects? Evidence from Slovenian firms. *Review of*

World Economics/Weltwirtschaftliches Archiv, 142(3), 599–614.

Danzon, P. M., & Keuffel, E. L. (2014). Regulation of the pharmaceutical-biotechnology industry. In *Economic Regulation and Its Reform: What Have We Learned?* (pp. 407-484). University of Chicago Press.

Davis, D. R. (1995). Intra-industry trade: A Heckscher-Ohlin-Ricardo approach. 39, 201–226.

Darwish, T. K., Zeng, J., Rezaei Zadeh, M., & Haak-Saheem, W. (2020). Organizational learning of absorptive capacity and innovation: does leadership matter? *European Management Review*, *17*(1), 83-100.

Department Of Higher Education and Training (2023). Global Competitiveness Fact Sheet. Available at https://lmi-research.org.za/wp-content/uploads/2023/03/DHET-PSET-FACTSHEET_SA-2022-Global-Competitiveness-Rankings_WEB.pdf .Accessed on 21 August 2023.

Department of Trade and Industry. Draft National Policy on Intellectual Property (2013). General Notice No.918, Government Gazette No 36816, 4 September 2013.

Department of Trade and Industry (2024). Positioning the local API industry as a regional development and manufacturing hub for the African Continent – policy considerations.

DePasse, J. W., & Lee, P. T. (2013). A model for 'reverse innovation in healthcare. *Globalization and health*, *9*, 1-7.

Ddudovskiy, J., 2012. Inter-industry and intra-industry trade. Heckscher-Ohlin Model. http://research-methodology.net/inter-industry-intra-industry-trade-heckscher-ohlinmodel/

Dornbusch, R., Fischer, S., & Samuelson, P. A. (1977). Comparative advantage, trade, and payments in a Ricardian model with a continuum of goods. *The American Economic Review*, *67*(5), 823-839.

Duh, H. I., & Diniso, C. (2020). Generic medicine brand knowledge structure, relationships and purchase. *International Journal of Pharmaceutical and Healthcare Marketing*, *14*(4), 493-512.

Durham, J. B. (2004). Absorptive capacity and the effects of foreign direct investment and equity foreign portfolio investment on economic growth. *European Economic Review*, *48*(2), 285–306.

Duvanova, D. (2012). Bureaucratic discretion and the regulatory burden: Business environments under alternative regulatory regimes. *British Journal of Political Science*, *42*(3), 573-596.

Eaton, J., & Kierzkowski, H. (1984). Oligopolistic competition, product variety, entry deterrence, and technology transfer. *The RAND Journal of Economics*, 99-107.

Elish, E., & Elshamy, H. (2017). Absorptive capacity of human capital and international R&D spillover on labour productivity in Egypt. *Managing Knowledge and Innovation for Business Sustainability in Africa*, 153-164.

Enkel, E., Heil, S., Hengstler, M., & Wirth, H. (2017). Exploratory and exploitative innovation: To what extent do the dimensions of individual level absorptive capacity contribute?. *Technovation*, *60*, 29-38.

Evenett, S.J., & Fritz, J. (2020). *Going it Alone? Trade Policy After Three Years of Populism*. Global Trade Alert.

Falvey, R., Foster, N. and Greenaway, D. (2007) 'Relative backwardness, absorptive capacity and knowledge spillovers', *Economics Letters*, 97(3), pp. 230–234. doi: https://doi.org/10.1016/j.econlet.2007.03.015.

Falvey, R.E. (1981). Commercial policy and intra-industry trade. *Journal of International Economics*, 11, 4: 495-511.

Fatti, A. & du Toit, A. (2013). Competitive intelligence challenges faced by South African pharmaceutical companies. *Asia Pacific Journal of Business and Management*, 4(1), pp. 39–54.

Ferreira Moutinho, R. F. (2016). Absorptive capacity and business model innovation as rapid development strategies for regional growth. *Investigación económica*, *75*(295), 157-202.

Findlay, Ronald. Comparative advantage.1991. In *The World of Economics*, pp. 99-107. London: Palgrave Macmillan UK.

Finger, J. M. (1975). Trade overlap and intra-industry trade. *Economic inquiry*, *13*(4), 581.

Flatten, T. C., Engelen, A., Zahra, S. A., & Brettel, M. (2011). A measure of absorptive capacity: Scale development and validation. *European Management Journal*, *29*(2), 98-116.

Fontagné, L., Freudenberg, M., & Gaulier, G. (2006). A systematic decomposition of world trade into horizontal and vertical IIT. *Review of World Economics*, *142*, 459-475.

Fontagné, L., Gueriné J. L., & Jean S. (2005). Market Access Liberalisation in the Doha Round: Scenarios and Assessment. *World Economy*, *28*(8), 1073-1094.

Foster-McGregor, N., Pöschl, J., & Stehrer, R. (2014). *Capacities and absorptive barriers for international R&D spillovers through intermediate inputs* (No. 108). wiiw Working Paper.

Friderichs, T. J., & Correa, F. M. (2022). Measuring human capital in South Africa across socioeconomic subgroups using a latent-variable approach. *Social Indicators Research, 164*(3), 1161–1185. https://doi.org/10.1007/s11205-022-02973-y

Fu, X., Pietrobelli, C., & Soete, L. (2011). The role of foreign technology and indigenous innovation in the emerging economies: technological change and catching-up. *World development*, *39*(7), 1204-1212.

Fuentes, J. R., & Mies, V. (2021). Technological Absorptive Capacity and Development Stage: Disentangling Barriers to Riches. *Macroeconomic Dynamics*, *25*(6), 1589-1624.

Gereffi, G. (2019). Economic upgrading in global value chains. *Handbook on global value chains*, 240-254.

Gkypali, A., Arvanitis, S. & Tsekouras, K. (2018). Absorptive capacity, exporting activities,

innovation openness, and innovation performance: A SEM approach towards a unifying framework, *Technological Forecasting and Social Change*. doi: 10.1016/j.techfore.2018.01.025.

Giachetti, C., & Lanzolla, G. (2016). Product technology imitation over the product diffusion cycle: Which companies and product innovations do competitors imitate more quickly?. *Long Range Planning*, *49*(2), 250-264.

Goldstein Research. (2021). *African Pharmaceuticals Industry Outlook: 2024 Edition*. https://www.goldsteinresearch.com/report/africa-pharmaceutical-industry-market-size-forecast.

Gokmenoglu, K. K., Amin, M. Y., & Taspinar, N. (2015). The relationship among international trade, financial development and economic growth: The case of Pakistan. *Procedia Economics and Finance*, *25*, 489-496.

Govindarajan, V., & Euchner, J. (2012). Reverse innovation. *Research-Technology Management*, *55*(6), 13-17.

Govindarajan, V., & Ramamurti, R. (2011). Reverse innovation, emerging markets, and global strategy. *Global Strategy Journal*, *1*(3-4), 191-205.

Gray, A., Suleman F, Bada P. (2017). South Africa's National Drug Policy: 20 years and still going? *South African Health Review*. 20th Edition.

Gray, H. P. (1976). A generalized theory of international trade. *Holmes and Meier*, New York.

Greenaway, D., Hine R.C., Milner, C. & Elliot R. (1995). Adjustment and the measurement of marginal intra-industry trade. *Weltwirtschaftliches Archiv*, 130, 2: 418-427

Greenaway, D., and Milner, C. (1983). On the measurement of intra-industry trade. *The Economic Journal*, *93*(372), 900-908

Griliches, Z. (1998). Issues in assessing the contribution of research and development to productivity growth. In *R&D and productivity: The econometric evidence* (pp. 17-45). University of Chicago Press.

Griffith, R., Redding, S., & Van Reenen, J. (2003). R&D and absorptive capacity: theory and empirical evidence. *Scandinavian Journal of Economics*, *105*(1), 99–118.

Grossman, G. M. and Helpman, E. (1991) 'Trade, knowledge spillovers, and growth', *European Economic Review*. doi: 10.1016/0014-2921(91)90153-A.

Grubel, H.G. and Lloyd P.J.,1975. *Intra-industry trade: the theory and measurement of international trade in differentiated products* (Vol. 12). London: Macmillan.

Gupta, S., Yadav, S. S., & Jain, P. K. (2022). Absorptive capacities, FDI and economic growth in a developing economy: a study in the Indian context. *Journal of Advances in Management Research*, *19*(5), 741-759.

Hair, J. F., Tomal G.TM., Sarstedt, M., & Ringle, C. M. (2017). A Primer on Partial Least Squares Structural Equation Modeling. Second Edition. SAGE Publications, Inc. United States of America.

Hair, J. F., Ringle, C. M., & Sarstedt, M. (2011). Pls-Sem: Indeed A Silver Bullet. *The Journal Of Marketing Theory And Practice*, *19*(2), 139–152. Https://Doi.Org/10.2753/Mtp1069-6679190202

Hamilton, C. & Kniest P.(1991). Trade liberalization, structural adjustment, and intra-industry trade: a note. *Weltwirtschaftliches Archiv*, 127, 2: 356-367.

Hanefeld, J., Modisenyane, M., Vearey, J., Lunt, N., Smith, R., & Walls, H. (2024). Bilateral health agreements of South Africa: an analysis of issues covered. *Health Policy and Planning*, *39*(7), 722-730.

Harris, R. & Yan, J. (2019) 'The Measurement Of Absorptive Capacity from an Economics Perspective: Definition, Measurement and Importance', *Journal of Economic Surveys*. doi: 10.1111/joes.12296.

Hatemi-J, A., & Irandoust M. (2001). Productivity performance and export performance: a time-series perspective. *Eastern Economic Journal*, *27*(2), 149-164.

Healthcare Financial Management Association (2014) Price transparency in health care. Available at https://www.hfma.org/transparency/.

Hausmann, R., Hwang, J., & Rodrik, D. (2007). What you export matters. *Journal of economic growth*, *12*, 1-25.

Helen Suzman Foundsation (2015). Pharmaceuticals in South Africa - An Enquiry. 2. https://hsf.org.za/publications/special-publications/pharmaceuticals-in-south-africa/pharmaceuticals-in-south-africa-an-enquiry-2.

Helpman, E., & Krugman, P. R. (1985). Market Structure and Foreign Trade, MIT Press, Cambridge, MA.

Helpman, E. (1981). International trade in the presence of product differentiation, economies of scale and monopolistic competition: A Chamberlin-Heckscher-Ohlin approach. *Journal of International Economics*, *11*(3), 305–340.

Heckscher, E. (1919). The effect of foreign trade on the distribution of income. *Ekonomisk Tidskriff*: 497–512. Translated as chapter 13 in American Economic Association, *Readings in the theory of international trade*. Philadelphia: Blakiston, 1949, and a new translation is provided in Flam and Flanders,1991.

Hiley, Mark.1999. The dynamics of changing comparative advantage in the Asia-Pacific region. *Journal of the Asia Pacific Economy* 4, no. 3: 446-467. https://doi.org/10.1080/13547869908724693

Hinloopen, Jeroen, and Charles Van Marrewijk. 2001. On the empirical distribution of the Balassa index. *Weltwirtschaftliches archiv* 137, no.1:1-35.. https://doi.org/10.1007/bf02707598

Horner, R. (2021). Global value chains, import orientation, and the state: South Africa's

pharmaceutical industry. *Journal of International Business Policy*, 1–20.

Hu, A. G., & Pang, D. (2013). *Patent rights and innovation by foreign firms*. National Bureau of Economic Research. https://doi.org/10.3386/w19460

Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural equation modeling: a multidisciplinary journal*, *6*(1), 1-55.

Huma, S., Muslim, S., & Ahmed, W. (2024). Understanding the role of organizational intellectual capital on developing absorptive capacity to strategize innovation ambidexterity. *Review of International Business and Strategy*, *34*(3), 433-453.

Hurtado, A., & González-Campo, C. H. (2015). Measurement Of Knowledge Absorptive Capacity: An Estimated Indicator For The Manufacturing Sector In Colombia. *Journal of Globalization, Competitiveness and Governability*, *9*(2).

Imbriani, C., Pittiglio, R., Reganati, F., & Sica, E. (2014). How much do technological gap, firm size, and regional characteristics matter for the absorptive capacity of Italian enterprises? *International Advances in Economic Research*, *20*, 57-72.

Imam, M. A., Saini, W. A., Ibrahim, S., & Mohamad, W. N. W. (2024) Institutional Quality, Income, and FDI: Unravelling Their Impact on Environmental Degradation in Developing Economies. *International journal of academic research in business & social sciences.*

Innovative Pharmaceutical Association South Africa. (2019). Available at https://ipasa.co.za.

Irwin, D. A. (2019). *US trade policy in historical perspective* (No. w26256). National Bureau of Economic Research.

Isemonger, A. G. (2000). The estimation of intra-industry trade in South Africa. *Development Southern Africa*, *17*(1), 53-63.

ITC Trade Map. (2022). Trade Map data portal. Available at: https://trademap.org/

Jajri, I., & Ismail, R. (2018). Determinants of total factor productivity in Malaysia. *Jurnal Ekonomi Malaysia, 52*(1), 211–225. https://doi.org/10.17576/JEM-2018-5201-17

Janadari, M. P. N., Sri Ramalu, S., Wei, C., & Abdullah, O. Y. (2016). Evaluation of measurment and structural model of the reflective model constructs in PLS–SEM. In *Proceedings of the 6th International Symposium—2016 South Eastern University of Sri Lanka (SEUSL), Oluvil, Sri Lanka* (pp. 20-21).

Jawahar, N., & Vidhya T. Lakshmi. (2017). Regulatory requirements for the drug approval process in US, Europe and India. *Journal of Pharmaceutical Sciences and Research* 9, no. 10: 1943-1952.

Joint Health and Treasury Task Team. (2003). Financing of the HIV/AIDS programme in South Africa. *Report of the Joint Health and Treasury Task Team*. Pretoria: National Department of Health.

Jung, J., & López-Bazo, E. (2017). Factor accumulation, externalities, and absorptive capacity in regional growth: evidence from Europe. *Journal of Regional Science*, *57*(2), 266-289.

Kahiya, E. T. (2018). Five decades of research on export barriers: Review and future

directions. *International Business Review*, *27*(6), 1172-1188.

Kaplan, W., & Laing, R. (2005). Local production of pharmaceuticals: industrial policy and access to medicines, an overview of key concepts, issues and opportunities for future research.

Kaufmann, D., Kraay, A., & Mastruzzi, M. (2010). *The worldwide governance indicators: Methodology and analytical issues*. World Bank Policy Research Working Paper No. 5430.

Keller, W. (1996). Absorptive capacity: On the creation and acquisition of technology in development. *Journal of Development Economics*, *49*(1), 199–227.

Kim, L. (1995). Absorptive capacity and industrial growth: A conceptual framework and Korea's experience. In *Social capability and long-term economic growth* (pp. 266–287). London: Palgrave Macmillan UK.

Kierzkowsk, H.,(1987). Recent advances in international trade theory: a selective survey. *Oxford Review of Economic Policy*, *3*(1), 1-19.

Kinoshita, Y., & Lu, C. H. (2006). On the role of absorptive capacity: FDI matters to growth.

Kinoshita, Y. (2000). R&D and technology spillovers via FDI: Innovation and absorptive capacity. *Available at SSRN 258194*.

Kline, R. B. (2023). *Principles and practice of structural equation modeling*. Guilford publications.

Kneller, R., & Stevens, P. A. (2002). *Absorptive capacity and frontier technology*. mimeo.

Kónya, L. (2006). Exports and growth: Granger causality analysis on OECD countries with a panel data approach. *Economic modelling*, *23*(6), 978-992.

Kaplan, W., & Laing, R. (2005). Local production of pharmaceuticals: industrial policy and access to medicines, an overview of key concepts, issues and opportunities for future research.

Kozłowski, W. (2011). Product Life Cycle Theories–Implications for marketing. *ECONOMIC*, 275.

Krogstrup, S., & Matar, L. (2005). Foreign direct investment, Absorptive capacity and Growth in the Arab world.

Krugman, P. R., & Obstfeld, M. (2009). *Internationale Wirtschaft: Theorie und Politik der Außenwirtschaft*. Pearson Deutschland GmbH.

Krugman, P. (1991). Increasing returns and economic geography. *Journal of political economy*, *99*(3), 483-499.

Krugman, P. (1986). *Strategic Trade Policy and the New International Economics*. MIT Press.

Krugman, P.(1984). Import protection as export promotion: International competition in the presence of oligopoly and economies of scale. *Imperfect competition and international trade*, 75-86.

Krugman, P. R. (1981). Intra-industry specialization and the gains from trade. *Journal of Political Economy*, *89*(5), 959-973.

Krugman, P. R. (1979). Increasing returns, monopolistic competition, and international trade. *Journal of International Economics*, *9*(4), 469-479.

Lancaster, K. (1980). Intra-industry trade under perfect monopolistic competition. *Journal of International Economics*, *10*(2), 151–175.

Lane, P. J., Koka, B. R., & Pathak, S. (2006). The reification of absorptive capacity: A critical review and rejuvenation of the construct. *Academy of Management Review*, *31*(4), 833-863.

Lee, H., (2004). *Regime selection as an alternative to Grubel Lloyd Index*, Konkuk University, Seoul

Leamer, E. E. (1980). The Leontief paradox, reconsidered. *Journal of political Economy*, *88*(3), 495-503.

Leontief, W. (1953). Domestic Production and Foreign Trade: The American Capital Position Re-Examined, *Proceedings of the American Philosophical Society*, 97(4), pp. 332-349.

Lenox, M., & King, A. (2004). Prospects for developing absorptive capacity through internal information provision. *Strategic Management Journal*, *25*(4), 331–345.

Lewin, A. Y., Massini, S., & Peeters, C. (2011). Microfoundations of internal and external absorptive capacity routines. *Organization Science*, *22*(1), 81–98.

Liao, J., Welsch, H., & Stoica, M. (2003). Organizational absorptive capacity and responsiveness: An empirical investigation of growth-oriented SMEs. *Entrepreneurship Theory and Practice*, *28*(1), 63-86.

Limaj, E. and Bernroider, E. W. N. (2019). The roles of absorptive capacity and cultural balance for exploratory and exploitative innovation in SMEs, *Journal of Business Research*. doi: 10.1016/j.jbusres.2017.10.052.

Linder, S. B. (1961). *An essay on trade and transformation* (Doctoral dissertation, Stockholm School of Economics).

Liengaard, B. D., Sharma, P. N., Hult, G. T. M., Jensen, M. B., Sarstedt, M., Hair, J. F., & Ringle, C. M. (2021). Prediction: coveted, yet forsaken? Introducing a cross-validated predictive ability test in partial least squares path modeling. *Decision Sciences*, *52*(2), 362-392.

Liu, X., & White, R. S. (1997). The relative contributions of foreign technology and domestic inputs to innovation in Chinese manufacturing industries. *Technovation*, *17*(3), 119–125.

Lohmöller, J. B., & Lohmöller, J. B. (1989). Predictive vs. structural modeling: Pls vs. ml. *Latent variable path modeling with partial least squares*, 199-226.

London Politica (2022). *South African healthcare: A system in crisis*. https://londonpolitica.com/africa-watch-blog-list/south-african-healthcare

Lund, A. (2006). Absorptive capacity and innovative performance: A human capital approach. *Economics of innovation and New Technology*, *15*(4-5), 507-517.

Malodia, S., Gupta, S., & Jaiswal, A. K. (2020). Reverse innovation: a conceptual framework. *Journal of the Academy of Marketing Science*, *48*, 1009–1029.

Maloney, C. & Segal, N.(2007). The growth potential of the pharmaceuticals sector in South Africa. Industry sector analysis report, Genesis Analytics (Pty) Ltd, Johannesburg.

Mahajan, Varun, Dinesh Kumar Nauriyal, & S. P. Singh. (2015). Trade performance and revealed comparative advantage of Indian pharmaceutical industry in new IPR regime. *International Journal of Pharmaceutical and Healthcare Marketing* 9, no. 1: 56-73.

McKinsey (2019). *Africa's pharmaceutical industry: A focus on local manufacturing*. https://www.mckinsey.com/industries/public-and-social-sector/our-insights/africas-pharmaceutical-industry.

Michaely, M. (1996), Trade preferential agreements in Latin America: an ex-ante assessment, Policy Research Working Paper 1583, Washington D.C.: The World Bank

Miguel Benavente, J. (2006). The role of research and innovation in promoting productivity in Chile. *Economics of innovation and New Technology*, *15*(4-5), 301-315.

Melitz, M. J., & Trefler, D. (2012). Gains from trade when firms matter. *Journal of Economic Perspectives*, *26*(2), 91-118.

Melitz, M. J. (2003). The impact of trade on intra-industry reallocations and aggregate industry productivity. *econometrica*, *71*(6), 1695-1725.

Menon, J. & Dixon, P. (1997). Intra-industry versus inter-industry trade: relevance for adjustment costs. *Weltwirtschaftliches Archiv*, 133, 1: 164-169.

Meeus, M. T., Oerlemans, L. A., & Hage, J. (2001). Patterns of interactive learning in a high-tech region. *Organization Studies*, *22*(1), 145-172.

Matthews, L., Hair, J. O. E., & Matthews, R. (2018). PLS-SEM: The holy grail for advanced analysis. *Marketing Management Journal*, *28*(1), 1-13.

Manrique, G. G. (1987). Intra-industry trade between developed and developing countries: The United States and the NICs. *The Journal of Developing Areas*, 481-494.

Minbaeva, D. B., Pedersen, T., Björkman, I., Fey, C. F., & Park, H. J. (2003). *MNC knowledge transfer, subsidiary absorptive capacity, and HRM*. Journal of International Business Studies, 34(6), 586–599. https://doi.org/10.1057/palgrave.jibs.8400056

Mingyong, L., Shuijun, P., & Qun, B. (2006). Technology spillovers, absorptive capacity, and

economic growth. *China Economic Review*, *17*(3), 300-320.

Moeti, L., Madira., & Jacques, J. (2023). Regulatory registration timelines of generic medicines in South Africa: Assessment of the performance of SAHPRA between 2011 and 2022. *Journal of Pharmaceutical Policy and Practice* 16, no. 1: 34.

Montague, C., & Oosthuizen, H. (2010). Growing the fruits of HIV/AIDS. *Leadership Lab*, *4*(1), 22.

Moodley, R., and Suleman, F.(2019). The impact of the single exit price policy on a basket of generic medicines in South Africa, using a time series analysis from 1999 to 2014. *Plos one*, *14*(7), e0219690.

Moshoeshoe, R. J., Enslin, G. M., & Katerere, D. R. (2022). An exploratory assessment of the legislative framework for combating counterfeit medicines in South Africa. *Journal of Pharmaceutical Policy and Practice*, *15*(1), 3.

Mousavi, S. Z., Rasekhi, S., Golestani, M., & Imani, A. (2018). Studying international competitiveness in the pharmaceutical sector in selected developed countries. *Asian Journal of Pharmaceutical and Clinical Research, 11*(3), 451–460.

Mowery, D. C., Oxley, J. E., & Silverman, B. S. (1996). Strategic alliances and interfirm knowledge transfer. *Strategic Management Journal*, *17*(S2), 77–91.

Mozambique expands drug manufacturing for local and international markets (2024). . *FurtherAfrica*. Available at: https://furtherafrica.com/2024/09/19/mozambique-expands-drug-manufacturing-for-local-and-international-markets/

Mumbauer, A. E., Stein, D. J., & Wolvaardt, G. G. (2024). Targeting youth mental health in a demographically young country: a scoping review focused on South Africa. *International Review of Psychiatry*, 1-13.

Mukherjee, A., Mitchell, W., & Talbot, F. B. (2000). The impact of new manufacturing requirements on production line productivity and quality at a focused factory. *Journal of Operations Management*, *18*(2), 139–168.

Mullor-Sebastian, A. (1983). The product life cycle theory: Empirical evidence. *Journal of International Business Studies*, *14*, 95-105.

Müller, J. M., Buliga, O. & Voigt, K. I. (2020). The role of absorptive capacity and innovation strategy in the design of industry 4.0 business Models-A comparison between SMEs and large enterprises, *European Management Journal*. doi: 10.1016/j.emj.2020.01.002.

Marire, J. (2020). Analysis of Changes in Total Factor Productivity for Academic Departments of Historically Privileged Small University in South Africa. *progressive*, *12*(18).

Muscio, A. (2007). The impact of absorptive capacity on SMEs' collaboration. *Economics of Innovation and New Technology*, *16*(8), 653–668.

Muzaka, V. (2023). *The pharmaceutical patent system and access to medicines.* In *Handbook on the Political Economy of Health Systems* (pp. 380-395). Edward Elgar Publishing.

Najafi-Tavani, S., Najafi-Tavani, Z., Naudé, P., Oghazi, P., & Zeynaloo, E. (2018). How collaborative innovation networks affect new product performance: Product innovation

capability, process innovation capability, and absorptive capacity. *Industrial marketing management*, *73*, 193-205.

National Industrial Policy Framework. (2014). 1–54. Available at http://www.thedtic.gov.za/sectors-and-services-2/industrial-development/national-industrial-policy-framework/.

National Development Plan (2030). Our Future – Make it work. National Planning Commission. Department of The Presidency. Republic of South Africa.

Narula, R. (2004). R&D collaboration by SMEs: new opportunities and limitations in the face of globalisation. *Technovation*, *24*(2), 153-161.

Ncube, C., & Rutenberg, I. (2021). Intellectual property and Fourth Industrial Revolution technologies1. *Leap 4.0: African Perspectives on the Fourth Industrial Revolution*, 393.

Neary, J. Peter. Competitive versus comparative advantage. 2003. *World Economy* 26, no. 4: 457-470.

Nerkar, A., & Roberts, P. W. (2004). Technological and product-market experience and the success of new product introductions in the pharmaceutical industry. *Strategic Management Journal*, *25*(8-9), 779-799.

Nielsen, J. U. M., & Pawlik, K. (2007). *The export intensity of foreign affiliates in transition economies: The importance of the organization of production*. SSRN.

Niyimbanira, F., & Surujlal, J. (2011). An analysis of economic impacts of the 2010 FIFA World Cup in South Africa marketing. *African Journal for Physical Health Education, Recreation and Dance*, *17*(sup-2), 255-266.

North, D. (1990). Institutions, Institutional Change and Economic Performance. *Ambridge: Cambridge University Press.*

Nunn, N., & Trefler, D. (2014). Domestic institutions as a source of comparative advantage. In G. Gopinath, E. Helpman, & K. Rogoff (Eds.), *Handbook of International Economics* (Vol. 4, pp. 263–315). Elsevier.

Ngozwana, S. (2016). Policies to control prices of medicines: does the South African experience have lessons for other African Countries?. *Making Medicines in Africa: The Political Economy of Industrializing for Local Health*, 203-223.

Nqeketo, S., & Sagandira, C. (2024). Towards continuous flow manufacturing of active pharmaceutical ingredients in Africa: a perspective. *Reaction Chemistry & Engineering*.

Nte, N. D., Omede, K. N., Enokie, B. K., & Bienose, O. (2020). Competitive intelligence and competitive advantage in pharmaceutical firms in developing economies: A review of Lagos State, Nigeria. *Journal of Management, Economics, and Industrial Organization, 4*(1), 76–99.

Flor, M. L., & Oltra, M. J. (2004). Identificationof innovating firms through technological innovation indicators: an application to the Spanish ceramic tile industry. *Research Policy*, *33*(2), 323-336.

O'Donnel, C. J. (2012). An aggregate quantity framework for measuring and decomposing

productivity change. *Journal of Productivity Analysis*, *38*, 255-272.

OECD. (2023). Gross national income (GNI*)*. Organisation for Economic Co-operation and Development. https://www.oecd.org/en/data/indicators/gross-national-income.html

Ohlin, B. (1933). Interregional and international trade. Harvard University Press

Orthofer, A. (2017). Wealth inequality in South Africa: Insights from survey and tax data. Available at https://www.econ3x3.org/sites/default/files/articles/Orthofer%202016%20Wealth%20distribution%20and%20tax%20data%20FINAL.pdf.

Ottaviano, G. I. (2011). 'New'new economic geography: firm heterogeneity and agglomeration economies. *Journal of Economic Geography*, *11*(2), 231-240.

Osland, G. E. (1991). Origins and development of the product life cycle concept.

Ostraszewska, Z., & Tylec, A. (2015). Reverse innovation–how it works. *International Journal of Business and Management*, *3*(1), 57-74.

Pawlak, K., & Lukasiewicz, J. (2022). Does intra-industry specialisation enhance or limit comparative advantage? Evidence from the world citrus fruit trade. *Agricultural Economics/Zemědělská Ekonomika*, *68*(9).

Parliamentary Monitoring Group (2017). Pharmaceutical Industry: Department of Health and DTI briefing. Available at https://pmg.org.za/committee-meeting/24697/. Date of access 21 August 2023.

Parr, R. G. (2000). Specialisation in South African manufactures trade, 1993-1998. *South African Journal of Economics*, *68*(2), 132–137. https://doi.org/10.1111/j.1813-6982.2000.tb01170.x

PC4IR. (2020). Report of the Presidential Commission on the Fourth Industrial Revolution. Pretoria: Government of South Africa.

Pham, T. T. T., & Riedel, J. (2013). *An Empirical Analysis of Comparative Advantage Dynamics* (No. 633). FREIT Working Paper.

Phillips, G., (2023). The pharmaceutical industry in South Africa, *African Business Information*, 19 July, 2024, viewed from https://www.whoownswhom.co.za/ store/pharmaceutical-industry-south-africa/.

Peterson, T. M., & Thies, C. G. (2012). Beyond Ricardo: The link between intra-industry trade and peace. *British Journal of Political Science*, *42*(4), 747-767.

Perkins, D. H., Radelet, S., Lindauer, D. L., & Steven, A. Block. (2013). Economics of Development.

Poniatowicz, M., Dziemianowicz, R., & Kargol-Wasiluk, A. (2020). Good governance and institutional quality of public sector: Theoretical and empirical implications. *European Research Studies Journal, 23*(2), 529–556. https://doi.org/10.35808/ersj/1608

Porter, M. E. (2011). *Competitive advantage of nations: creating and sustaining superior performance*. Simon Schuster.

Posner, M. V. (1961). International Trade And Technical Change. Oxford Economic Papers, 13(3), 323–341. http://dx.doi.org/ 10.1093/oxfordjournals.oep.a040877.

Purnama, P. D., & Yao, M. H. (2019). The relationship between international trade and economic growth: an empirical finding from ASEAN countries. *International Journal of Applied Business Research*, 112-123.

Qian, H. & Acs, Z. J. (2013). 'An absorptive capacity theory of knowledge spillover entrepreneurship', *Small Business Economics*. doi: 10.1007/s11187-011-9368-x.

Rayment, C. (2020). "Pharmaceutical industry South Africa and India bilateral". Economic Diplomacy & States Division. Ministry of External Affairs.

Reuters (2021). South Africa sells AstraZeneca COVID-19 vaccines to other African countries. Available at: https://www.reuters.com/business/healthcare-pharmaceuticals/south-africa-sells-astrazeneca-covid-19-vaccines-other-african-countries-2021-03-21/. Accessed on 02/04/2025

Ricardo, D. (1821). *On the principles of political economy and taxation* (3rd ed.). John Murray.

Ricci, L.A. & Trionfetti, F., (2012). Productivity, networks, and export performance: Evidence from a cross-country firm dataset, *Review of International Economics* 20(3), 552–562. https://doi.org/10.1111/j.1467-9396.2012.01038.x

Roberts, M. & Tybout, J., (1997). The decision to export in Colombia: An empirical model of entry with Sunk Costs, *American Economic Review* 87(1997), 545–563.

Rodrik, D., Subramanian, A., & Trebbi, F. (2004). Institutions rule: the primacy of institutions over geography and integration in economic development. *Journal of economic growth*, *9*, 131-165.

Roper, S., Love, J. H., & Bonner, K. (2017). Firms' knowledge search and local knowledge externalities in innovation performance. *Research policy*, *46*(1), 43-56.

Ruffin, R. (2002). David Ricardo's discovery of comparative advantage. *History of political economy*, *34*(4), 727–748.

Ruffin, R. J., 1999. The nature and significance of intra-industry trade. *Economic and Financial Review-Federal Reserve Bank of Dallas*, (4), 2–16.

Salikhova, O. B. 2020. Comparative advantages of national pharmaceutical industries through the prism of new indicators. *Statistics of Ukraine* 8990, no. 2-3: 48-58.

Salem, R. A., Lila, S., & Lewaaelhamd, I. (2025). The impact of Russian–Ukrainian conflict on international financial markets: a comparative analysis of oil-importing and oil-exporting countries. *Journal of Chinese Economic and Foreign Trade Studies*.

Salomon, R. M., & Shaver, J. M. (2005). Learning by exporting: new insights from examining firm innovation. *Journal of Economics & Management Strategy*, *14*(2), 431-460.

Schneider, M., & Ho Tu Nam, N. (2020). Africa and counterfeit pharmaceuticals in the times

of COVID-19. *Journal of Intellectual Property Law & Practice*, *15*(6), 417-418.

Schultz,T. W. (1961) Investment in human capital. *The American economic review* 51, no. 1 (1961): 1-17.

Schumacher, R. (2013). Deconstructing the theory of comparative advantage. *World Social and Economic Review, 2013*(2), 83.

Shmueli, G., Sarstedt, M., Hair, J. F., Cheah, J. H., Ting, H., Vaithilingam, S., & Ringle, C. M. (2019). Predictive model assessment in PLS-SEM: guidelines for using PLSpredict. *European journal of marketing*, *53*(11), 2322-2347.

Sen, A. (1999). Health in development. *Bulletin of the World Health Organization*, *77*(8), 619.

Simson, R. A. (1987). Intra-industry trade in South Africa (Doctoral dissertation).

Sichei, M. M., Harmse C., & Kanfer F. (2007). Determinants of South Africa- US intra-industry trade in services: a wild bootstrap dynamic panel data analysis 1. *South African Journal of Economics*, *75*(3), 521-539.

Siregar, O. M., Ridho, H., Nasution, M. A., & Nasution, M. D. T. P. (2024). Knowledge Dynamics and Absorptive Capacity: Shaping Innovation Performance in the Service Business of Small and Medium-Sized Enterprises. *International Review of Management and Marketing*, *14*(5), 53-66.

South African Health Products Regulating Authority (2023). Product Recalls. Available at https://www.sahpra.org.za.

South African Medical Research Council (2023). Government and leading medical and pharmaceutical associations to collaborate on research and development. 27 January 2023. Available at https://www.samrc.ac.za/press-releases/government-and-leading-medical-and-pharmaceutical-associations-collaborate-research#:~:text=%22Since%202016%2C%20innovative%20multinational%20pharmaceutical,in%20them%2C%22%20said%20Durham.

Spender, J. C. (1996). Making knowledge the basis of a dynamic theory of the firm. *Strategic management journal*, *17*(S2), 45-62.

Statistics South Africa. (2015). *Education Series Volume III: Educational Enrolment and Achievement, 2013*.

Statistica, 2023. Consumer Price Index of medical products in South Africa. https://www.statista.com/statistics/1122790/south-africa-monthly-cpi-medical-products/.

Stock, G. N., Greis, N. P., & Fischer, W. A. (2001). Absorptive capacity and new product development. *The Journal of High Technology Management Research*, *12*(1), 77-91.

Stolper, W. F., & Samuelson, P. A. (1941). Protection and Real Wages, *Review of Economic Studies*, 9(1), pp. 58-73.

Storper, M., & Venables, A. J. (2004). Buzz: face-to-face contact and the urban economy. *Journal of economic geography*, *4*(4), 351-370.

Stuart, John. 2023. Gender, Value Chains and MSMEs in Africa: Exploring Primary Survey Data for the Pharmaceuticals Sector.tralac Trade Brief No IDRC23TR05/2023.Stellenbosch:tralac.

Strøm-Andersen, N. (2020) 'Innovation and by-product valorization: A comparative analysis of the absorptive capacity of food processing firms', *Journal of Cleaner Production*. doi: 10.1016/j.jclepro.2019.119943.

Su, Y., Yuan, D., Chen, D. G., Ng, R. H., Wang, K., Choi, J., ... & Heath, J. R. (2022). Multiple early factors anticipate post-acute COVID-19 sequelae. *Cell*, *185*(5), 881-895.

Sustainable Development Goals. (2030). Transforming the world: The 2030 Agenda for Sustainable Development. *United Nations*. A/RES/70/1.

Tanaka, H. (2006). Dynamic analysis of imitation and technology gap. *Journal of Economics*, *87*, 209-240.

Tang, Y., & Zhang, K. H. (2016). Absorptive capacity and benefits from FDI: Evidence from Chinese manufactured exports. *International Review of Economics & Finance*, *42*, 423-429.

Taylor, B. (2007). Rationing of medicines and health care technology. In Harrison, S., Bahna, R. & Ntuli, A. (eds.). South African Health Review 2007. Durban: Health Systems Trust, pp. 123-137

Te Naudé C. W., & Luiz J. M. (2013). An industry analysis of pharmaceutical production in South Africa. *South African Journal of Business Management*, *44*(1), 33–46. https://doi.org/10.4102/sajbm.v44i1.146.

Thenga, G. (2021). An evaluative study of criminalistics: a case of South African counterfeiting and knock-off menace. *Open J. Legal Stud.*, *4*, 45.

Todorova, G., & Durisin, B. (2007). Absorptive capacity: Valuing a reconceptualization. *Academy of management review*, *32*(3), 774-786.

Tödtling, F., & Trippl, M. (2011). 33 Regional innovation systems. *Handbook of regional innovation and growth*, 455.

Tomlinson, C., Waterhouse C. , Hu Y. Q., Meyer S., & Moyo H. (2019). How patent law reform can improve affordability and accessibility of medicines in South Africa: Four medicine case studies. *South African Medical Journal* 109, no. 6: 387-391.

Trademap (2023). Trade statistics for international business development. Available at: https://www.trademap.org/Index.aspx

Sinanan, D., & Hosein, R. (2012). Transition Probability Matrices and Revealed Comparative Advantage Persistence in a Small Oil-based Economy. *West Indian Journal of Engineering*.

Solow, R. M. (1957). Technical change and the aggregate production function. *The review of Economics and Statistics*, *39*(3), 312-320.

South Africa exports to Zimbabwe. (2024). *Trading Economics*. Available at: https://tradingeconomics.com/south-africa/exports/zimbabwe

South Africa exports to Mozambique. (2024). *Trading Economics*. Available at: https://tradingeconomics.com/south-africa/exports/mozambique

South Africa exports to Namibia. (2024). *Trading Economics*. Available at: https://tradingeconomics.com/south-africa/exports/namibia.

Trump, D.J. (2020). Executive Order on Ensuring Essential Medicines, Medical Countermeasures, and Critical Inputs Are Made in the United States. *The White House*.

Teece, D. J. (1977). Technology transfer by multinational firms: The resource cost of transferring technological know-how. *The economic journal*, *87*(346), 242-261.

Tsai, M. C., & Wang, C. (2017). Linking service innovation to firm performance: The roles of ambidextrous innovation and market orientation capability. *Chinese Management Studies*, *11*(4), 730-750.

Udokporo, C. K. (2021). Understanding the Stages of the Product Life Cycle. In *Product Life Cycle-Opportunities for Digital and Sustainable Transformation*. IntechOpen.

UN Comtrade. (2022). South Africa's pharmaceutical trade statistics. Available at: https://comtrade.un.org. Accessed on 10 March 2025.

UNDP. (2020). *Human Development Report 2020*. United Nations Development Programme

Urbach, N., & Ahlemann, F. (2010). Structural Equation Modeling In Information Systems Research Using Partial Least Squares. *Journal Of Information Technology Theory And Application*, *11*(2), 5–40. Https://Doi.Org/10.1037/0021-9010.90.4.710.

U.S. Food and Drug Administration. (2019). *Safeguarding pharmaceutical supply chains in a global economy*.Available at: https://www.fda.gov/news-events/congressional-testimony/safeguarding-pharmaceutical-supply-chains-global-economy-10302019.

Valdaliso, J., Elola, A., Aranguren, M., & Lopez, S. (2011). Social capital, internationalization and absorptive capacity: The electronics and ICT cluster of the Basque Country. *Entrepreneurship & Regional Development*, *23*(9-10), 707-733.

Von Zedtwitz, M., Corsi, S., Søberg, P. V., & Frega, R. (2015). A typology of reverse innovation. *Journal of Product Innovation Management*, *32*(1), 12-28.

Vahter P. (2010). Does FDI spur innovation, productivity and knowledge sourcing by incumbent firms? Evidence from manufacturing industry in Estonia. Evidence from Manufacturing Industry in Estonia. University of Nottingham Research Paper, (2010/09).

Velásquez, G. (2015). *Guidelines on patentability and access to medicines* (No. 61). Research Paper.

Verdoorn, P. J. (1960). The intra-bloc trade of Benelux. In *Economic Consequences of the Size of Nations: Proceedings of a Conference held by the International Economic Association* (pp. 291-329). London: Palgrave Macmillan UK.

Vernon R. (1966). International investment and international trade in the product cycle. Quarterly Journal of Economics, 80, 190-207.

Veitch, C., 2020. The Pharmaceutical Industry Report. *Who Owns Whom*. African Business Information. December 2020. Available at https://www.whoownswhom.co.za/.

Vinzi, V. E. (2010). Handbook of partial least squares.

Viviers, W. Lubbe, M., Steenkamp E., & Olivier, D. (2014). The Identification Of Realistic Export Opportunities For The South African Pharmaceutical Industry. *International Business & Economics Research Journal (IBER)*, *13*(2), 231. https://doi.org/10.19030/iber.v13i2.8438

Veugelers, R. (1997). Internal R&D expenditures and external technology sourcing. *Research Policy*, *26*(3), 303–315.

Vollrath, Thomas L. (1991). A theoretical evaluation of alternative trade intensity measures of revealed comparative advantage. *Weltwirtschaftliches Archiv* 127, no. 2: 265-280. https://doi.org/10.1007/BF02707986

Wang, Q., Xu, W., & Cheng, R. (2025). Exploring the evolution of global beef trade network patterns based on complex network analysis. *Frontiers in Sustainable Food Systems*, *9*, 1490578.

Warr, P. G. (1994). Comparative and competitive advantage. *Asian-Pacific Economic Literature* 8, no. 2 (1994): 1-14.

Wen, Y. F., & Matsaneng, T. (2014). *Patents, pharmaceuticals and competition: Benefitting from an effective patent examination system*.

World Bank. (2021). *World Development Indicators*. https://data.worldbank.org/

World Bank. (2023). *World Development Indicators*. https://data.worldbank.org/

World Health Organisation (2024) Substandard and Falsified Medical Products. Available online at https://www.who.int/news-room/fact-sheets/detail/substandard-and-falsified-medical-products. Accessed on 01/04/2025.

World Bank. (2024). India country economic memorandum: Unlocking the potential of cities for economic growth. Available at: https://thedocs.worldbank.org/en/doc/400139d320ead96a0ec624d3608d9b56-0310012025/original/India-Country-Economic-Memorandum-2024-0227c.pdf

World Economic Forum. (2023). AfCFTA: A New Era for Global Business and Investment in Africa. *Insight report, January 2023*.

World Economic Forum (2018). Global Competitiveness Report. Available at.https://www.weforum.org/reports/the-global-competitveness-report-2018/. Date of access: 25 August 2023.

World Integrated Trade Solutions (2024). Tariffs. Available at: https://wits.worldbank.org. Accessed on 01 June 2024.

Williamson, O. E. (2007). *The economic institutions of capitalism. Firms, markets, relational contracting* (pp. 61-75). Gabler.

Xia, T., & Roper, S. (2016). Unpacking open innovation: Absorptive capacity, exploratory and exploitative openness, and the growth of entrepreneurial biopharmaceutical firms. *Journal of Small Business Management*, *54*(3), 931–952.

Yao, F. K., Jiang, K., Combs, D. R., & Chang, S. (2020). Informal institutions and absorptive capacity: A cross-country meta-analytic study. *Journal of International Business Studies*, 1-19.

Yong, A. G., & Pearce, S. (2013). A beginner's guide to factor analysis: Focusing on exploratory factor analysis. *Tutorials in quantitative methods for psychology*, *9*(2), 79-94.

Yu, R., Junning C., & PingSun L. (2009). The normalized revealed comparative advantage index. *The annals of regional Science* 43: 267-282. https://doi.org/10.1007/s00168-008-0213-3.

Yusefzadeh, H., Rezapour, A., Lotfi, F., Ebadifard Azar, F., Nabilo, B., Abolghasem Gorji, H., Hadian, M., Shahidisadeghi, N., & Karami, A. (2015). A study of comparative advantage and intra-industry trade in the pharmaceutical industry of Iran. *Global Journal of Health Science, 7*(6), 295.

Zahra, S., & George, G. (2002). Absorptive capacity: A review, reconceptualization, and extension. Academy of Management Review, 27(2), 185–203.

Zou, T., Ertug, G. & George, G. (2018). The capacity to innovate: a meta-analysis of absorptive capacity, *Innovation: Management, Policy and Practice*. doi: 10.1080/14479338.2018.1428105.

Zou, B., Guo, F., & Guo, J. (2016). Absorptive capacity, technological innovation, and product life cycle: a system dynamics model. *SpringerPlus*, *5*, 1-25.

Zornoza, C. C., Julián, B. F., & Navarro, M. B. (2015). A Review of Absorptive Capacity. *Encyclopedia of Information Science and Technology, Third Edition*, 4446-4455.

Appendices

Appendix A: Recalled Medicine in South Africa

Table 3: Examples of recalled medicine from May 2021 to August 2023

Company name	registration number	First distributed	Recall Classification	Recall Date
Pfizer Laboratories (Pty) Ltd	41/24/0432	12/04/19	Class III Type B	19/08/2021
Adcock Ingram limited	B/2.8/858	11/2020	Class II Type B	13/07/2021
	B/2.7/1404	12/2020	Class II Type B	
Sanofi-Aventis South Africa	40/7.1.3/0287	28/05/20	Class II Type B	27/10/2021
	40/7.1.3/0288	12/02/21	Class II Type B	27/10/2021
Cipla Medpro (Pty) Ltd	H1511 (Act 101/1965)	09/20	Class III Type C	24/01/2022
iNova Pharmaceuticals (Pty) Ltd	34/16.4/0391	13/12/2021	Class III Type C	28/01/2022
Pfizer Laboratories (Pty) Ltd	34/7.1.3/0230	19/10/19	Class II Type B	25/04/2022
Pfizer Laboratories (Pty) Ltd	-	20/05/20	Class II Type B	25/04/22
	G/2.6/188	21/07/20	Class II Type B	04/07/22
Cipla Medpro (Pty) Ltd	W/16.3/58	04/02/2021	Class I Type A	15/06/22
Adcock Ingram Limited	B/2.8/1401	25/06/21	Class II Type B	23/06/22
	JANUMET 50/850mg	06/07/2022	Class III Type C	05/09/2022
Sanofi Aventis South Africa (Pty) Ltd/Zentiva Pharmaceuticals (Pty) Ltd	V/18.1/9	22/04/2022	Class II Type C	17/10/2022

Dr Reddy's Laboratories (Pty) Ltd	43/2.6.5/0432	24/02/23	Class III Type C	07/07/23
B.Braun Medical (Pty) Ltd	41/24/0432	03/05/21	Class II Type B	02/08/2023

Source: Adapted from SAPRAH (2023) available at https://www.sahpra.org.za.

Appendix B: South Africa's world trade in pharmaceuticals

South Africa's world trade in pharmaceuticals and percentage of exports to SADC. Unit: US$ thousand

Year	Imports in USD from ROW	Exports in USD to ROW	Pharmaceutical Trade balance	% Share of pharm exports on total X	%Share of pharm import on total M	% Share of SA's pharm exports to SADC
2002	587852	83617	-504235	0.36	2.55	27,6
2003	772241	89387	-682854	0.28	2.44	27.71
2004	961415	108455	-852960	0.27	2.39	33.58
2005	1168572	120531	-1048041	0.26	2.49	28.95
2006	1330743	120093	-1210650	0.23	2.53	26.41
2007	1475429	142396	-1333033	0.22	2.30	28.76
2008	1569555	177867	-1391688	0.24	2.12	33.76
2009	1588134	178183	-1409951	0.33	2.95	37.19
2010	2074511	386809	-1687702	0.47	2.51	73.24
2011	2202356	462183	-1740173	0.43	2.04	73.69
2012	2366798	431673	-1935125	0.44	2.39	68.42
2013	2272462	432720	-1839742	0.46	2.39	65.86
2014	2068704	429570	-1639134	0.46	2.23	63.85
2015	2178581	402472	-1776109	0.50	2.71	63.89
2016	1893409	420409	-1473000	0.55	2.49	54.57
2017	2238147	450912	-1787235	0.51	2.54	61.54
2018	2501754	429299	-2072455	0.46	2.67	67.78
2019	2421100	434067	-1987033	0.49	2.71	62.28
2020	2401518	392121	-2009397	0.46	2.82	59.36
2021	3065610	894213	-2171397	0.73	2.50	30.98

Source: Author's own computation using data from Trademap (2020

Appendix C: Extended patents and inflated prices

Table 25. Patents granted on Trastuzumab in South Africa

PATENT TITLE	PATENT HOLDER	CIPC NUMBER	LODGING DATE	GRANT DATE	EXPIRY DATE	LEGAL STATUS	PCT NUMBER
Protein purification by ion exchange chromatography	Genentech Inc.*	2000/05879	20-October-2000	22-Oct-2001	20-Octo-2020	Granted	PCT/US99/09637
Dosages for treatment with anti-erbb2 antibodies	Genentech Inc.	2002/01229	13-Feb-2002	25-Jun-2023	13-Feb-2022	Granted	PCT/US00/23391
Her-2 antibody composition	Genentech Inc.	2007/01234	2-Feb-2007	31-Dec-2008	2-Feb 2027	Granted	PCT/US05/025084
Combinations of an anti-her-2 antibody-drug conjugate and chemotherapeutic agents, and methods of use	Genentech Inc.	2010/06186	30-Aug-2010	30-Nov-2011	30-Aug-2030	Granted	PCT/US09/036608
Treatment of her-2-positive cancer with paclitaxel and trastuzumab-mcc-dm1	Genentech Inc.	2013/03611	17-May-2013	30-Jul-2014	17-May-2033	Granted	

Table 26. Prices of Trastuzumab in South Africa and India

DOSAGE AND FORMULATION	PRICES OF ORIGINATOR PRODUCTS IN SA PRIVATE SECTOR [2]	PRICES OF ORIGINATOR PRODUCTS IN SA PUBLIC SECTOR [1]	PRICES OF ORIGINATOR PRODUCT IN INDIA [11]	PRICES OF CLONE PRODUCT IN INDIA [11]	PRICES (IN ZAR) OF BIOSIMILAR PRODUCT IN INDIA [11]
440 mg vial ++	ZAR 55.20 US$ 3.90	Unknown	ZAR60.71 US$ 4.29	ZAR 30.70 US$ 2.17 (Roche/Emcure)	ZAR 17.22 US$1.22 (Biocon/Mylan)
440 mg vial +	ZAR 24,290.00 US$1,717.82	Unknown	ZAR 26.723.00 US$ 1.889.89	ZAR 13.524.00 US$ 956.44 (Roche/Emcure)	ZAR 7.576 US$535.79 (Biocon/Mylan)
150 mg vial ++					ZAR 18.75 US$1.32 (Biocon/Mylan)
150 mg vial +					ZAR 2,813.00 US$198.94 (Biocon/Mylan)

+price per single vial ++price per single mg

Table 27. Prices of Bortezomb in South Africa and India

Generic versions of bortezomib are available in India at prices 75% lower than those charged for the originator Product in South Africa.

PATENT TITLE	PATENT HOLDER	CIPC NUMBER	LODGING DATE	GRANT DATE	EXPIRY DATE	LEGAL STATUS	PCT NUMBER
Boronic ester and acid compounds,synthesis and uses	Millennium Pharmaceuticals	1995/09119	27-Octo-1995	31-Jul-1996	27-Oct-2015	Granted	PCT/US1995/014117
Boronate ester compounds and pharmaceutical compositions thereof	Millennium Pharmaceuticals	2010/09177	21-Dec-2010	28-Mar-2012	21-Dec-2030	Granted	PCT/US09/003602
Boronate ester compounds and pharmaceutical compositions thereof	Millennium Pharmaceuticals	2011/09368	20- Dec-2011	30-Octo-2013	20-Dec-2031	Granted	N/A
Boronate ester compounds and pharmaceutical compositions thereof	Millennium Pharmaceuticals	2015/04133	08-Jun-2015	N/A	8-Jun-2035	Granted	N/A

Table 28. Prices of Trastuzumab in South Africa and India

Dosage and formulation	Prices of originator products in SA private sector [2]	Prices of originator products in SA public sector [1]	Prices of generic products in India [1]	Prices of originator product in India [11]
3.5 mg/ml vial++	ZAR 4,178.70 US$ 295.52	N/A	ZAR 1.079.22 US$76.32 (Natco, Glenmark)	ZAR 3,692.87 US$ 261.16
3.5 mg/ml vial+	ZAR 14,625.46 US$ 1,034.33		ZAR 3.777.27 US$267.13 (Natco, Glenmark)	ZAR 12,925.00 US$ 914.07
2mg/ml vial++			ZAR 1.338.33 US$94.64 (Natco, Glenmark)	
2mg/ml vial+			ZAR 2.676.66 US$189.30 (Natco, Glenmark)	

Appendix D: Proxies for measuring absorptive capacity

Table 5: Empirical studies using various proxies to measure absorptive capacity

Author	Research topic	Dimension/proxy
Flatten, Engelen, Zahra, and Brettel (2011)	A Measure of Absorptive Capacity: Scale Development and Validation	Acquisition, Assimilation, transformation, and Exploitation
Camisón and Forés (2010)	Knowledge absorptive capacity: New insights for its conceptualization and measurement	**Potential absorptive capacity (CAPOT)** **Acquisition capacity:** Knowledge of the competition, Openness towards the environment, R&D cooperation, and Internal development of technological competencies. **Assimilation capacity:** Assimilation of technology, Human resources Industrial benchmarking, Involvement in spreading knowledge, Attendance at training courses and professional events, Knowledge management. **Realized absorptive capacity.** **Transformation capacity:** Transmission of IT-based knowledge, Renewal capability, Adaptation capacity Exchange of scientific and technological information, Integration of R&D **Application capacity:** New knowledge exploitation, Application of experience Development of patents, Technological proactiveness
Kim (1995)	Absorptive Capacity and Industrial Growth: A Conceptual Framework and Korea's Experience	**Prior knowledge:** Formal education, General education Technical education, Vocational training **Intensity of efforts:** Research and development, production
Zahra and George (2002)	Absorptive capacity: a review, Reconceptualization, and extension.	**Acquisition:** Prior Investments, Prior knowledge, Intensity, Speed, and Direction **Assimilation:** Understanding **Transformation:** Internalization and Conversion **Exploitation:** Use and Implementation
Keller (1995)	Absorptive capacity: On the creation and acquisition of technology in development.	Human capital
Durham (2004)	Absorptive capacity and the effects of foreign direct investment and equity foreign portfolio investment in economic growth.	Investment ratio, initial GDP per capita, Population growth, Education rate, FDI, Property rights index and Corruption index
Becker, Egger and von Ehrlich (2013)	Absorptive Capacity and the Growth and Investment Effects of Regional Transfers: A Regression Discontinuity Design with Heterogeneous Treatment Effects	Education of population and institutional quality
Zou et al. (2016)	Absorptive capacity, technological innovation, and product life cycle: a system dynamics model	An external knowledge network, research and development period, and knowledge diversity
Hurtado & González-Campo (2015).	Measurement of knowledge absorptive capacity: an estimated indicator for the manufacturing sector in Colombia.	**Acquisition:** R&D investment, Technology Transfer Investment, Investment in Machinery and Equipment. **Assimilation:** Supplier cooperation, Institution cooperation, Client cooperation.

		Transformation: Staff involved in Technology and innovation activities, Support in technical assistance and consulting. **Exploitation:** Innovation in production methods, improvement in the quality of products and/or services, Broadening the range of products and/or services.
mingy and Yan (2019)	The Measurement Of Absorptive Capacity from an Economics Perspective: Definition, Measurement and Importance	**Quantitative methods:** Patents, R&D Expenditure, and Human Capital **Qualitative methods:** Expert Surveys and Case Studies
Krogstrup and Matar (2005)	Foreign Direct Investment, Absorptive Capacity, and Growth in the Arab World	The technology gap, the level of workforce education, financial development and institutional quality
Castellacci and Natera (2015)	Innovation, absorptive capacity, and growth heterogeneity: Development paths in Latin America 1970–2010	Human capital and education
Xia and Roper (2016)	Unpacking Open Innovation: Absorptive Capacity, Exploratory and Exploitative Openness, and the Growth of Entrepreneurial Biopharmaceutical Firms	**Potential ACAP Indicators:** R&D Intensity, Employee Skills, Continuous R&D **Realised ACAP Indicators:** No. of Patents
Lewin, Massini, and Peeters (2011)	Microfoundations of Internal and External Absorptive Capacity Routines	**Internal and External Absorptive Capacity Routines:** Facilitating variation, Managing internal selection regimes, Sharing knowledge and superior practices across the organization Reflecting, updating, and replicating, Managing adaptive tension **Internal and External Absorptive Capacity Routines** identifying and recognizing the value of externally generated knowledge, Learning from and with partners, suppliers, customers, competitors, and consultants, Transferring knowledge back to the organization
Kinoshita and Lu (2006)	On the Role of Absorptive Capacity: FDI Matters to Growth	Infrastructure
Liao, Welsch and Stoica (2003)	Organizational Absorptive Capacity and Responsiveness: An Empirical Investigation of Growth-Oriented SMEs.	External knowledge acquisition, Intra firm knowledge dissemination
Griffith, Redding and John Van Reenen (2003)	R&D and Absorptive Capacity: Theory and Empirical Evidence	Research and development
Valdalisoa, Elolab, Arangurenb and Lopezc (2011)	Social capital, internationalization, and absorptive capacity: The electronics and ICT cluster of the Basque Country	social capital, internationalization
Castellani and Zanfei (2003)	Technology gaps, Absorptive Capacity and the impact of inward investments on productivity of European firms.	local firms' average productivity levels,

Mingyong, Shuijun and Qun (2006)	Technology spillovers, absorptive capacity, and economic growth	host country's degree of openness and human capital
Ahuja and Katila (2001)	Technological acquisition and firm performance: A longitudinal study	Number of patents
Belderbos, Carree, Diederen, Lokshin, and Veugelers (2004)	Heterogeneity in R&D co-operation strategies.	R&D-intensity
Boynton, Zmud, and Jacobs (1994)	Influence of IT Management processes concerning IT usage in large companies	IT knowledge of management
Cockburn and Henderson (1998)	Absorptive capacity, coauthoring behavior, and the organization of research in drug discovery	Number of academic publications
Lenox and King (2004)	ACAP development on the management level	Knowledge management (flow of information)
Liu and White (1997)	The relative contributions of foreign technology and domestic inputs to innovation in Chinese manufacturing industries	Investments in R&D employees
Meeus, Oerlemans, & Hage (2001)	Patterns of interactive learning in a high-tech region	R&D-intensity
Mowery, Oxley & Silverman (1996)	Strategic alliances and in-house knowledge transfer	Patents and R&D-intensity
Mukherjee, Mitchelle, and Talbot (2000)	The impact of new manufacturing requirements on production line productivity and quality at a focused factory	Labour productivity and compliance quality
Muscio (2007)	The impact of absorptive capacity on SMEs' collaboration	In-house items: degree of employees assigned with R&D activities or in-house education.
Nielsen and Pawlik (2007)	The export intensity of foreign affiliates in transition economies: The importance of the organization of production	Wage-level of foreign companies compared to the level of domestic companies.
Flor and Oltra, 2004	Identification of innovating firms through technological innovation indicators: an application to the Spanish ceramic tile industry	R&D-intensity
Stock, Greis, and Fischer (2001)	New product development	R&D-intensity
Tsai (2001)	Firm performance and innovation success	R&D-intensity
Vandenbosch, Volberda, and De Boer (1999)	Coevolution of firm absorptive capacity and knowledge environment: organizational forms and combinative capabilities	Incentive system
Veugelers (1997)	Internal R & D expenditures and external technology sourcing	Employee of R&D, postgraduates in R&D, proportion of R&D in basic research
Lund Vinding (2006)	Absorptive capacity and innovative performance: A human capital approach.	HR management

Source: Flatten et al. (2011) and Author's own construction.

Appendix E: Decomposition of Total Factor Productivity Change

The components of Total Factor Productivity (equation 3) are estimated as follows:

$$Technical\ change = \left[\frac{d_0^t\left(X_{t-1},Y_{t-1}\right)}{d_0^{t-1}\left(X_{t-1},Y_{t-1}\right)} * \frac{d_0^t\left(X_t,Y_t\right)}{d_0^{t-1}\left(X_t,Y_t\right)}\right]^{\frac{1}{2}} \quad (4)$$

Equation (7) shows the production technologies (or frontiers) for periods t and t-1, respectively. Since productivity can be assessed in relation to either the previous period's production technology or the current period's production technology, a geometric mean of these two measures is employed to calculate technical change. Equation (4) asserts that if the productivity evaluated in the current period's production technology differs from the previous period's production technology, it indicates technical change – an inward or outward shift in the production function. If it exceeds one, it suggests technological progress. An index of unity indicates that the DMU remains on the frontier, indicating best practice or benchmarking.

$$Technical\ efficiency\ change = \frac{d_0^t\left(X_t,Y_t\right)}{d_0^{t-1}\left(X_{t-1},Y_{t-1}\right)} \quad (5)$$

In equation(5), it is stated that when comparing the productivity levels in the current period based on the current technology to the productivity in the previous period based on the previous period's technology (as illustrated in figure 1) are different, it indicates a change in technical efficiency. This change occurs when the producer moves to or further away from their production frontier. For instance, this movement could involve transitioning from point A toward or away from d_0^{t-1} in period t-1 and from point B toward or away from d_0^t in period t (as depicted in Figure 1). This index can assume values greater than one (indicating an improvement in efficiency), less than one (indicating a decline in efficiency), or equal to one (indicating that the producer is operating at the frontier.

$$Scale\ efficiency\ change\ (SEC) = \left[\frac{SEC_0^{t-1}\left(X_t,Y_{t-1}\right)}{SEC_0^{t-1}\left(X_{t-1},Y_{t-1}\right)} * \frac{SEC_0^t\left(X_t,Y_t\right)}{SEC_0^t\left(X_{t-1},Y_t\right)}\right]^{\frac{1}{2}} \quad (6)$$

Equation 6 articulates that in the Malquist approach to analysing total factor productivity change, scale efficiency change is determined by taking the geometric mean of two

components: scale efficiency change concerning the previous period's production technology and the previous period's output and scale efficiency change concerning the current period's production technology and current period's output. Scale efficiency change can exceed one, which indicates that the input set used is closer to the technically optimal scale than the input set used in the previous period. An index of unity implies that the current period's production experiences global constant returns to scale.

$$\textit{Output mix effect} = \left[\frac{SE_0^{t-1}(X_{t-1},Y_t)}{SE_0^{t-1}(X_{t-1},Y_{t-1})} * \frac{SE_0^{t}(X_t,Y_t)}{SE_0^{t}(X_t,Y_{t-1})}\right]^{\frac{1}{2}} \quad (7)$$

Equation (7) expresses that the alteration in the output mix effect is derived as a geometric mean of scale efficiency (SE) concerning the previous period's production technology and scale efficiency concerning the current period's production technology. The output mix effect quantifies the impact of a shift in the composition of output on the scale efficiency for the given period. This measurement can take the form of on (indicating an increase in the output mix effect), less than one (suggesting a decrease in the output mix effect), or exactly on (indicating no change in the output mix).

Appendix F: Alternative Constructs of the Balassa Index

Table 10. Balassa Index and its alternative constructs

Index	Formula	Range	Mean	Proposed by
$BI^k_{(i)}$ Balassa Index Or $BRCA^k_{(i)}$ Balassa Revealed Comparative Advantage Index	$\frac{\frac{X^k_{(i)}}{X_{(i)}}}{\frac{X^k_{(w)}}{X_{(w)}}} = \frac{P^k_{(ix)}}{P^k_{(wx)}} = RCA^k_{(ix)}$ **i** = Country i. **k** = commodity k. **w** = World. **X** = exports	$[0, \infty]$	Variable	Balassa (1965). Balassa (1965 cited in Hinloopen and Van Marrewijk, 2001:4). Yu *et al*. (2009:268)
$RXA^k_{(i)}$ Relative export advantage	$\text{In}\left(RXA^k_i\right)$ **i** = Country i. **k** = commodity k	$[-\infty, \infty]$	Variable	Vollrath (1991:275)
RTA Index Relative Trade Advantage Index	$\frac{\frac{X^k_{(i)}}{Xn_{(i)}}}{\frac{X^k_{(r)}}{Xn_{(r)}}} - \frac{\frac{M^k_{(i)}}{Mn_{(i)}}}{\frac{M^k_{(r)}}{Mn_{(r)}}}$ **i** = Country i. **k** = commodity k. **n** = all commodities minus commodity k. **r** = World minus Country i. **X** = exports. **M** = imports.	$[-\infty, \infty]$	Variable	Vollrath (1991:275)
RC Index Revealed Competitiveness	$In\left(\frac{\frac{X^k_{(i)}}{Xn_{(i)}}}{\frac{X^k_{(r)}}{Xn_{(r)}}}\right) - In\left(\frac{\frac{M^k_{(i)}}{Mn_{(i)}}}{\frac{M^k_{(r)}}{Mn_{(r)}}}\right)$	$[-\infty, \infty]$	Variable	Vollrath (1991)
$RSCA^k_{(ix)}$ Revealed Symmetric Comparative Advantage	$\frac{RCA^k_{(i)} - 1}{RCA^k_{(i)} + 1}$	$[-1,1]$	Variable	Dalum et al. (1998:427). Laursen (1998 cited in Yu et al, 2009:269)

[a]$WRCA^{k}_{(ix)}$ Weighted Revealed Comparative Advantage. $\boldsymbol{N_s}$ is the number of sectors, **i** = Country i. **k** = commodity k. **w** = World, **X** = exports	$\dfrac{\dfrac{X^{k}_{(i)}}{X_{(i)}}\Big/\dfrac{X^{k}_{(w)}}{X_{(w)}}}{\dfrac{1}{N_s}\sum_{k=1}^{N_1}\dfrac{X^{k}_{(i)}}{X_{(i)}}\Big/\dfrac{X^{k}_{(w)}}{X_{(w)}}}$	$[0, N_1]$	1	Proudman and Redding (2000) Liu and Gao (2019)
[b]$B^{k}_{(ix)}$ International Specialisation Index $\boldsymbol{N_c}$ is the number of countries.	$\dfrac{\dfrac{X^{k}_{(i)}}{X_{(i)}}\Big/\dfrac{X^{k}_{(w)}}{X_{(w)}}}{\dfrac{1}{N_c}\sum_{i=1}^{N_c}\dfrac{X^{k}_{(i)}}{X_{(i)}}\Big/\dfrac{X^{k}_{(w)}}{X_{(w)}}}$	$[0, N_1]$	1	Amador *et al*. (2011)
Additive RCA ($ARCA^{k}_{(ix)}$)	$\frac{X^{k}_{i}}{X_{(i)}} - \frac{X^{k}_{(w)}}{X_{(w)}}$	$[-1, 1]$	0	Hoen and Oosterhaven (2006)
Normalized RCA ($NRCA^{k}_{(ix)}$)	$\dfrac{X^{k}_{(i)}}{X_{(w)}} - \dfrac{X_{(i)}}{X_{(w)}}\dfrac{X^{k}_{(w)}}{X_{(w)}}$	$\left[-\frac{1}{4}, \frac{1}{4}\right]$	0	Yu *et al*. (2009)
[c]$RCA_{i,k}$	$\dfrac{z_{ik} * z_{..}}{Z_{i.} * Z_{.k}}$	$[0, \infty]$	Variable	Leromain and Orefice (2014)

Source: Adapted from Liu and Gao (2019:3)

Note:[a] Here, N_s is the number of sectors. Therefore, the metric ranges from 0 to N_s, and its mean is 1 across sectors in a country.

[b] Similarly, N_c is the number of countries, the metric ranges from 0 to N_c, and its mean is 1 across all the countries in a sector.

[c] z_{ik} is a good proxy for comparative advantage, $z_{..}$ is the average of all z_{ik} coefficients across all industries and countries, $Z_{i.}$ is the average of z_{ik} for the country *i* across all sectors and $Z_{.k}$ is the average of z_{ik} for the sector *k* across all exporters.

Appendix G: NRCA results for selected African countries

Table 12. Normalised Revealed Comparative (Dis) Advantage of South Africa

Product Code	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2014*	*2016*	*2018*	*2020*	*2022*	*Mean*	*NRCA*
HS 3001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NO
HS 3002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0001	0.0000	NO
HS 3003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NO
HS 3004	-0.000001	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001	DIS
HS 3005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NO
HS 3006	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.000	0.000	0.0000	0.0000	NO

Table 13. Normalised Revealed Comparative (Dis) Advantage of Egypt

Product Code	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2014*	*2016*	*2018*	*2020*	*2022*	*Mean*	*NRCA*
HS 3001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000	0.000	NO
HS 3002	0.0003	0.0002	0.0001	0.000	0.000	0.000	0.000	0.000	0.000	0.0001	0.0000	0.0001	YES
HS 3003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000	0.0008	YES
HS 3004	0.0083	0.0040	0.0046	0.0101	0.0152	0.0140	0.0135	0.0139	0.0092	0.0122	0.0000	0.0094	YES
HS 3005	0.0004	0.0002	0.0001	0.0002	0.0002	0.0015	0.0030	0.0030	0.0023	0.0026	0.0000	0.0012	YES
HS 3006	0.000	0.000	0.000	0.000	0.001	0.001	0.003	0.003	0.002	0.003	0.0000	0.0000	NO

Table 14. Normalised Revealed Comparative (Dis) Advantage of Nigeria

Product Code	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2014*	*2016*	*2018*	*2020*	*2022*	*Mean*	*NRCA*
HS 3001	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NO
HS 3002	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NO
HS 3003	0.0000	0.0000	0.0000	0.0001	0.0002	0.0001	0.0002	0.0000	0.0000	0.0000	0.0000	0.0001	NO
HS 3004	-0.0001	0.0000	-0.0001	0.0000	-0.0001	-0.0001	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	NO
HS 3005	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NO
HS 3006	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NO

Table 15. Normalised Revealed Comparative (Dis) Advantage of Morocco

Product Code	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2014*	*2016*	*2018*	*2020*	*2022*	*Mean*	*NRCA*
HS 3001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NO
HS 3002	0.0001	0.0001	0.0001	0.0002	0.0001	0.0001	0.0002	0.0001	0.0003	0.0003	0.0000	0.0002	YES
HS 3003	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000	0.0002	0.0001	0.0001	0.0000	0.0000	0.0001	YES
HS 3004	0.0024	0.0021	0.0022	0.0031	0.0037	0.0042	0.0049	0.0056	0.0050	0.0056	0.0000	0.0034	YES
HS 3005	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0004	0.0000	0.0002	YES
HS 3006	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0003	0.0000	0.0000	0.0001	YES

Table 16. Normalised Revealed Comparative (Dis) Advantage of Algeria

Product Code	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2014*	*2016*	*2018*	*2020*	*2022*	*Mean*	*NRCA*
HS 3001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000	0.000	NO
HS 3002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000	0.000	NO
HS 3003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000	0.000	NO
HS 3004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000	0.000	NO
HS 3005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000	0.000	NO
HS 3006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000	0.000	NO

Table 17. Normalised Revealed Comparative (Dis) Advantage of Tunisia

Product Code	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2014*	*2016*	*2018*	*2020*	*2022*	*Mean*	*NRCA*
HS 3001	0.0002	0.0001	0.0002	0.0001	0.0002	0.0002	0.0001	0.0002	0.0002	0.0000	0.0000	0.0001	YES
HS 3002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NO
HS 3003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NO
HS 3004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NO
HS 3005	0.0002	0.0002	0.0000	0.0000	0.0001	0.0001	0.0003	0.0003	0.0004	0.0000	0.0000	0.0002	YES
HS 3006	0.0006	0.0014	0.0010	0.0014	0.0015	0.0021	0.0021	0.0024	0.0032	0.0000	0.0000	0.0015	YES

Table 18. Normalised Revealed Comparative (Dis) Advantage of Kenya

Product Code	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2014*	*2016*	*2018*	*2020*	*2022*	*Mean*	*NRCA*
HS 3001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000	0.000	NO
HS 3002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000	0.000	NO
HS 3003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000	0.000	NO
HS 3004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000	0.000	NO
HS 3005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000	0.000	NO
HS 3006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000	0.000	NO

Appendix H: NRCA results for selected emerging countries.

Table 20. Normalised Revealed Comparative (Dis) Advantage China

Product Code	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2014*	*2016*	*2018*	*2020*	*2022*	*Mean*	*NRCA*
HS 3001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	NO
HS 3002	-0.0001	-0.0002	-0.0002	-0.0003	-0.0005	-0.0006	-0.0007	-0.0010	-0.0011	-0.0019	-0.0020	-0.0007	DIS
HS 3003	0.0000	0.0000	0.0000	0.0000	-0.0001	0.0000	0.0000	-0.0001	-0.0001	0.0000	0.0000	0.0000	NO
HS 3004	-0.0010	-0.0013	-0.0016	-0.0017	-0.0021	-0.0019	-0.0022	-0.0027	-0.0024	-0.0033	-0.0024	-0.0020	DIS
HS 3005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NO
HS 3006	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001	-0.0001	0.0000	NO

Table 21. Normalised Revealed Comparative (Dis) Advantage of India

Product Code	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2014*	*2016*	*2018*	*2020*	*2022*	*Mean*	*RCA*
HS 3001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NO
HS 3002	0.0000	0.0000	0.0000	0.0000	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001	-0.0002	-0.0002	-0.0001	DIS
HS 3003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NO
HS 3004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0002	0.0004	0.0004	0.0006	0.0004	0.0002	YES
HS 3005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NO
HS 3006	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NO

Table 22. Normalised Revealed Comparative (Dis) Advantage of Brazil

Product Code	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2014*	*2016*	*2018*	*2020*	*2022*	*Mean*	*NRCA*
HS 3001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NO
HS 3002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0001	-0.0001	-0.0002	0.0000	NO
HS 3003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NO
HS 3004	-0.0002	-0.0002	-0.0002	-0.0002	-0.0003	-0.0002	-0.0002	-0.0002	-0.0002	-0.0003	-0.0002	-0.0002	DIS
HS 3005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NO
HS 3006	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NO

Appendix I: NRCA for Selected Developed Countries.

Table 24. Normalized Revealed Comparative (Dis) Advantage of Switzerland

Product Code	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2014*	*2016*	*2018*	*2020*	*2022*	*Mean*	*NRCA*
HS 3001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NO
HS 3002	0.0004	0.0005	0.0005	0.0008	0.0010	0.0011	0.0013	0.0015	0.0014	0.0020	0.0018	0.0011	YES
HS 3003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NO
HS 3004	0.0012	0.0013	0.0014	0.0013	0.0016	0.0014	0.0016	0.0021	0.0020	0.0023	0.0016	0.0016	YES
HS 3005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NO
HS 3006	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NO

Table 25. Normalised Revealed Comparative (Dis) Advantage of Belgium

Product Code	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2014*	*2016*	*2018*	*2020*	*2022*	*Mean*	*NRCA*
HS 3001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0008	0.0007	0.0006	0.0000	0.0000	NO
HS 3002	0.0002	0.0002	0.0002	0.0003	0.0004	0.0005	0.0007	0.0006	0.0007	0.0013	0.0023	0.0007	YES
HS 3003	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NO
HS 3004	0.0022	0.0022	0.0020	0.0019	0.0018	0.0012	0.0011	0.0011	0.0010	0.0012	0.0010	0.0015	YES
HS 3005	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NO
HS 3006	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	YES

Table 26. Normalised Revealed Comparative (Dis) Advantage of Netherlands

Product Code	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2014*	*2016*	*2018*	*2020*	*2022*	*Mean*	*NRCA*
HS 3001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NO
HS 3002	0.0000	0.0001	0.0001	-0.0001	-0.0001	0.0000	-0.0001	-0.0001	-0.0001	0.0000	0.0003	0.0000	NO
HS 3003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NO
HS 3004	0.0001	0.0001	0.0001	-0.0001	0.0001	0.0002	0.0003	0.0002	0.0003	0.0004	0.0006	0.0002	YES
HS 3005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NO
HS 3006	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	NO

Table 27. Normalised Revealed Comparative (Dis) Advantage France

Product Code	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2014*	*2016*	*2018*	*2020*	*2022*	*Mean*	*NRCA*
HS 3001	0.1817	0.1680	0.1902	0.1803	0.3109	0.2847	0.3800	0.3423	0.3376	0.4688	0.0000	0.2505	YES
HS 3002	0.0178	0.0201	0.0215	0.0227	0.0361	0.0468	0.0333	0.0244	0.0244	0.0346	0.0004	0.0260	YES
HS 3003	0.0037	0.0417	0.0365	0.0324	0.0396	0.0391	0.0301	0.0313	0.0320	0.0294	0.0000	0.0302	YES
HS 3004	0.0187	0.0179	0.0146	0.0127	0.0098	0.0120	0.0140	0.0145	0.0185	0.0157	0.0011	0.0133	YES
HS 3005	0.0385	0.0324	0.0288	0.0393	0.0243	0.0222	0.0422	0.0481	0.0216	0.0220	0.0000	0.0296	YES
HS 3006	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NO

Table 28. Normalized Revealed Comparative (Dis) Advantage of Italy

Product Code	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2014*	*2016*	*2018*	*2020*	*2022*	*Mean*	*NRCA*
HS 3001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NO
HS 3002	0.0000	0.0000	0.0000	-0.0001	-0.0001	-0.0001	-0.0001	0.0000	0.0001	0.0001	0.0001	0.0000	NO
HS 3003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NO
HS 3004	0.0004	0.0002	0.0003	0.0002	0.0003	0.0005	0.0007	0.0005	0.0005	0.0009	0.0009	0.0004	YES
HS 3005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NO
HS 3006	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NO

Table 29. Normalised Revealed Comparative (Dis) Advantage of the United Kingdom's

Product Code	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2014*	*2016*	*2018*	*2020*	*2022*	*Mean*	*NRCA*
HS 3001	0.0001	0.0002	0.0002	0.0002	0.0003	0.0004	0.0005	0.0006	0.0005	0.0004	0.0000	0.0003	YES
HS 3002	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001	0.0000	-0.0001	0.0000	-0.0001	-0.0001	-0.0001	-0.0001	DIS
HS 3003	0.0014	0.0014	0.0011	0.0010	0.0011	0.0009	0.0011	0.0012	0.0008	0.0008	0.0000	0.0010	NO
HS 3004	-0.0008	-0.0008	-0.0007	-0.0006	-0.0006	-0.0004	-0.0005	-0.0005	-0.0005	-0.0005	0.0005	-0.0005	DIS
HS 3005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NO
HS 3006	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NO

Table 30. Normalised Revealed Comparative (Dis) Advantage of Germany

Product Code	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2014*	*2016*	*2018*	*2020*	*2022*	*Mean*	*NRCA*
HS 3001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NO
HS 3002	0.0001	0.0003	0.0002	0.0004	0.0006	0.0006	0.0007	0.0007	0.0008	0.0008	0.0009	0.0005	Yes
HS 3003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0000	0.0000	0.0000	NO
HS 3004	0.0001	0.0007	0.0010	0.0012	0.0011	0.0012	0.0013	0.0013	0.0014	0.0016	0.0018	0.0011	Yes
HS 3005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NO
HS 3006	0.0001	0.0001	0.0001	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	YES

Table 31. Normalized Revealed Comparative (Dis) Advantage of the United States of America

Product Code	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2014*	*2016*	*2018*	*2020*	*2022*	*Mean*	*NRCA*
HS 3001	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	NO
HS 3002	0.0002	0.0002	0.0003	0.0004	0.0004	0.0001	0.0002	0.0005	0.0004	0.0004	0.0018	0.0004	YES
HS 3003	0.0000	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	NO
HS 3004	-0.0007	-0.0004	-0.0004	-0.0003	-0.0002	-0.0001	-0.0003	-0.0005	-0.0005	-0.0006	0.0014	-0.0002	DIS
HS 3005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NO
HS 3006	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	NO

Appendix J: Commodity comparisons for African countries

Table 32: South Africa's cross-commodity NRCA results

South Africa cross-commodity comparison					Value in 2001	
Product code	**'3006**	**'3005**	**'3001**	**'3004**	**'3003**	**'3002**
'3006	0	1.4337E-06	1.7321E-06	-5.676E-05	1.4925E-06	-4.4221E-06
'3005	-1.43368E-06	0	2.9845E-07	-5.82E-05	5.883E-08	-5.8558E-06
'3001	-1.73213E-06	-2.985E-07	0	-5.849E-05	-2.396E-07	-6.1542E-06
'3004	5.67622E-05	5.8196E-05	5.8494E-05	0	5.8255E-05	5.23401E-05
'3003	-1.49251E-06	-5.883E-08	2.3962E-07	-5.825E-05	0	-5.9146E-06
'3002	4.42209E-06	5.8558E-06	6.1542E-06	-5.234E-05	5.9146E-06	0
SA cross-commodity comparison					**Value in 2005**	
Product code	**'3006**	**'3005**	**'3001**	**'3004**	**'3003**	**'3002**
'3006	0	2.0703E-06	1.9952E-06	-7.905E-05	3.3158E-06	-8.5133E-06
'3005	-2.07033E-06	0	-7.511E-08	-8.112E-05	1.2455E-06	-1.0584E-05
'3001	-1.99522E-06	7.5111E-08	0	-8.105E-05	1.3206E-06	-1.0508E-05
'3004	7.90508E-05	8.1121E-05	8.1046E-05	0	8.2367E-05	7.05376E-05
'3003	-3.31583E-06	-1.246E-06	-1.321E-06	-8.237E-05	0	-1.1829E-05
'3002	8.51328E-06	1.0584E-05	1.0508E-05	-7.054E-05	1.1829E-05	0
SA cross-commodity comparison					**Value in 2010**	
Product code	**'3006**	**'3005**	**'3001**	**'3004**	**'3003**	**'3002**
'3006	0	9.0093E-07	4.007E-07	-9.174E-05	-2.698E-07	-2.4468E-05
'3005	-9.00926E-07	0	-5.002E-07	-9.264E-05	-1.171E-06	-2.5369E-05
'3001	-4.00699E-07	5.0023E-07	0	-9.214E-05	-6.705E-07	-2.4869E-05
'3004	9.17408E-05	9.2642E-05	9.2142E-05	0	9.1471E-05	6.72723E-05
'3003	2.69823E-07	1.1707E-06	6.7052E-07	-9.147E-05	0	-2.4199E-05
'3002	2.44685E-05	2.5369E-05	2.4869E-05	-6.727E-05	2.4199E-05	0
SA cross-commodity comparison					**Value in 2015**	
Product code	**'3006**	**'3005**	**'3001**	**'3004**	**'3003**	**'3002**
'3006	0	2.0931E-07	4.7608E-07	-7.803E-05	9.0796E-08	-3.2724E-05
'3005	-2.09309E-07	0	2.6677E-07	-7.824E-05	-1.185E-07	-3.2934E-05
'3001	-4.7608E-07	-2.668E-07	0	-7.851E-05	-3.853E-07	-3.3201E-05
'3004	7.80312E-05	7.8241E-05	7.8507E-05	0	7.8122E-05	4.53068E-05
'3003	-9.07959E-08	1.1851E-07	3.8528E-07	-7.812E-05	0	-3.2815E-05

'3002	3.27244E-05	3.2934E-05	3.3201E-05	-4.531E-05	3.2815E-05	0
SA cross-commodity comparison					**Value in 2020**	
Product code	**'3006**	**'3005**	**'3001**	**'3004**	**'3003**	**'3002**
'3006	0	1.0445E-06	1.4575E-06	-9.647E-05	1.5374E-06	-6.0877E-05
'3005	-1.04451E-06	0	4.1303E-07	-9.751E-05	4.9289E-07	-6.1921E-05
'3001	-1.45754E-06	-4.13E-07	0	-9.793E-05	7.9868E-08	-6.2334E-05
'3004	9.64695E-05	9.7514E-05	9.7927E-05	0	9.8007E-05	3.5593E-05
'3003	-1.53741E-06	-4.929E-07	-7.987E-08	-9.801E-05	0	-6.2414E-05
'3002	6.08765E-05	6.1921E-05	6.2334E-05	-3.559E-05	6.2414E-05	0

**Positive values in red show a comparative advantage, and negative values show a comparative disadvantage.

Table 33: Nigeria cross-commodity NRCA results

Nigeria cross-commodity comparison					**Value in 2001**	
Product code	**'3006**	**'3005**	**'3001**	**'3004**	**'3003**	**'3002**
'3006	0	7.65E-07	1.59721E-06	-4.3E-05	1.97E-07	-3.8E-06
'3005	-7.64984E-07	0	8.32224E-07	-4.4E-05	-5.7E-07	-4.5E-06
'3001	-1.59721E-06	-8.3E-07	0	-4.5E-05	-1.4E-06	-5.4E-06
'3004	4.32808E-05	4.4E-05	4.4878E-05	0	4.35E-05	3.95E-05
'3003	-1.96708E-07	5.68E-07	1.4005E-06	-4.3E-05	0	-4E-06
'3002	3.76436E-06	4.53E-06	5.36157E-06	-4E-05	3.96E-06	0
Nigeria cross-commodity comparison					**Value in 2006**	
Product code	**'3006**	**'3005**	**'3001**	**'3004**	**'3003**	**'3002**
'3006	0	1.05E-06	8.0268E-06	-9.3E-05	-4.1E-08	-1.2E-05
'3005	-1.05046E-06	0	6.97634E-06	-9.4E-05	-1.1E-06	-1.3E-05
'3001	-8.0268E-06	-7E-06	0	-0.0001	-8.1E-06	-2E-05
'3004	9.25828E-05	9.36E-05	0.00010061	0	9.25E-05	8.08E-05
'3003	4.1431E-08	1.09E-06	8.06823E-06	-9.3E-05	0	-1.2E-05
'3002	1.17454E-05	1.28E-05	1.97722E-05	-8.1E-05	1.17E-05	0
Nigeria cross-commodity comparison					**Value in 2010**	
Product code	**'3006**	**'3005**	**'3001**	**'3004**	**'3003**	**'3002**
'3006	0	-2.4E-05	3.26526E-05	-0.00012	0.0002	-4.9E-05

'3005	2.3808E-05	0	5.64606E-05	-9.5E-05	0.000223	-2.5E-05
'3001	-3.26526E-05	-5.6E-05	0	-0.00015	0.000167	-8.2E-05
'3004	0.000118377	9.46E-05	0.000151029	0	0.000318	6.92E-05
'3003	-0.000199632	-0.00022	-0.000166979	-0.00032	0	-0.00025
'3002	4.92059E-05	2.54E-05	8.18585E-05	-6.9E-05	0.000249	0

Nigeria cross-commodity comparison					**Value in 2015**	
Product code	**'3006**	**'3005**	**'3001**	**'3004**	**'3003**	**'3002**
'3006	0	1.66E-06	3.74377E-06	3.03E-05	3.57E-05	-1.9E-05
'3005	-1.65517E-06	0	2.0886E-06	2.87E-05	3.4E-05	-2.1E-05
'3001	-3.74377E-06	-2.1E-06	0	2.66E-05	3.19E-05	-2.3E-05
'3004	-3.03052E-05	-2.9E-05	-2.65614E-05	0	5.35E-06	-4.9E-05
'3003	-3.56529E-05	-3.4E-05	-3.19091E-05	-5.3E-06	0	-5.5E-05
'3002	1.9178E-05	2.08E-05	2.29218E-05	4.95E-05	5.48E-05	0

Nigeria cross-commodity comparison					**Value in 2020**	
Product code	**'3006**	**'3005**	**'3001**	**'3004**	**'3003**	**'3002**
'3006	0	8.01E-07	1.17744E-06	-3.2E-05	1.71E-05	-2.4E-05
'3005	-8.00979E-07	0	3.76459E-07	-3.3E-05	1.63E-05	-2.5E-05
'3001	-1.17744E-06	-3.8E-07	0	-3.3E-05	1.59E-05	-2.5E-05
'3004	3.22149E-05	3.3E-05	3.33923E-05	0	4.93E-05	7.94E-06
'3003	-1.70527E-05	-1.6E-05	-1.58753E-05	-4.9E-05	0	-4.1E-05
'3002	2.42789E-05	2.51E-05	2.54563E-05	-7.9E-06	4.13E-05	0

Table 34: Egypt cross-commodity NRCA results

Egypt cross-commodity comparison					Value in 2001	
Product code	'3006	'3005	'3001	'3004	'3003	'3002
'3006	0	0.000383	-1.2E-05	0.00641	0.001085	3.3E-05
'3005	-0.00038	0	-0.0004	0.006027	0.000701	-0.00035
'3001	1.2E-05	0.000395	0	0.006422	0.001097	4.51E-05
'3004	-0.00641	-0.00603	-0.00642	0	-0.00533	-0.00638
'3003	-0.00108	-0.0007	-0.0011	0.005325	0	-0.00105
'3002	-3.3E-05	0.00035	-4.5E-05	0.006377	0.001052	0
Egypt cross-commodity comparison					Value in 2005	
Product code	'3006	'3005	'3001	'3004	'3003	'3002
'3006	0	0.000154	-2.8E-06	0.00566	0.000228	0.000216
'3005	-0.00015	0	-0.00016	0.005506	7.39E-05	6.22E-05
'3001	2.76E-06	0.000157	0	0.005663	0.000231	0.000219
'3004	-0.00566	-0.00551	-0.00566	0	-0.00543	-0.00544
'3003	-0.00023	-7.4E-05	-0.00023	0.005432	0	-1.2E-05
'3002	-0.00022	-6.2E-05	-0.00022	0.005444	1.17E-05	0
Egypt cross-commodity comparison					Value in 2010	
Product code	'3006	'3005	'3001	'3004	'3003	'3002
'3006	0	0.000186	-5.4E-06	0.015208	0.000903	8.16E-07
'3005	-0.00019	0	-0.00019	0.015022	0.000717	-0.00019
'3001	5.44E-06	0.000192	0	0.015213	0.000908	6.26E-06
'3004	-0.01521	-0.01502	-0.01521	0	-0.0143	-0.01521
'3003	-0.0009	-0.00072	-0.00091	0.014305	0	-0.0009
'3002	-8.2E-07	0.000185	-6.3E-06	0.015207	0.000902	0
Egypt cross-commodity comparison					Value in 2015	
Product code	'3006	'3005	'3001	'3004	'3003	'3002
'3006	0	0.002557	-6.5E-06	0.011579	0.001191	-4.2E-06
'3005	-0.00256	0	-0.00256	0.009022	-0.00137	-0.00256

'3001	6.49E-06	0.002564	0	0.011585	0.001197	2.32E-06
'3004	-0.01158	-0.00902	-0.01159	0	-0.01039	-0.01158
'3003	-0.00119	0.001366	-0.0012	0.010388	0	-0.00119
'3002	4.17E-06	0.002561	-2.3E-06	0.011583	0.001195	0
Egypt cross-commodity comparison					**Value in 2020**	
Product code	**'3006**	**'3005**	**'3001**	**'3004**	**'3003**	**'3002**
'3006	0	0.00248	-0.0001	0.012091	0.000181	-1.1E-05
'3005	-0.00248	0	-0.00258	0.009612	-0.0023	-0.00249
'3001	0.000102	0.002582	0	0.012194	0.000283	9.1E-05
'3004	-0.01209	-0.00961	-0.01219	0	-0.01191	-0.0121
'3003	-0.00018	0.002299	-0.00028	0.01191	0	-0.00019
'3002	1.12E-05	0.002491	-9.1E-05	0.012103	0.000192	0

Table 35. Morocco cross-commodity NRCA results

Morocco cross-commodity comparison					**Value in 2001**	
Product code	**'3006**	**'3005**	**'3001**	**'3004**	**'3003**	**'3002**
'3006	0	4.09E-05	-5.3E-05	0.002155	-5.1E-05	8.39E-05
'3005	-4.1E-05	0	-9.4E-05	0.002114	-9.2E-05	4.3E-05
'3001	5.27E-05	9.36E-05	0	0.002207	1.65E-06	0.000137
'3004	-0.00215	-0.00211	-0.00221	0	-0.00221	-0.00207
'3003	5.1E-05	9.19E-05	-1.7E-06	0.002206	0	0.000135
'3002	-8.4E-05	-4.3E-05	-0.00014	0.002071	-0.00013	0
Morocco cross-commodity comparison					**Value in 2005**	
Product code	**'3006**	**'3005**	**'3001**	**'3004**	**'3003**	**'3002**
'3006	0	7.52E-05	-0.0001	0.002168	-9.1E-05	-2.6E-05
'3005	-7.5E-05	0	-0.00018	0.002093	-0.00017	-0.0001
'3001	0.0001	0.000175	0	0.002268	8.91E-06	7.45E-05
'3004	-0.00217	-0.00209	-0.00227	0	-0.00226	-0.00219
'3003	9.13E-05	0.000166	-8.9E-06	0.002259	0	6.56E-05

'3002	2.57E-05	0.000101	-7.4E-05	0.002194	-6.6E-05	0
Morocco cross-commodity comparison					Value in 2010	
Product code	'3006	'3005	'3001	'3004	'3003	'3002
'3006	0	4.19E-05	-0.00013	0.003559	-0.00012	6.5E-06
'3005	-4.2E-05	0	-0.00017	0.003517	-0.00016	-3.5E-05
'3001	0.000125	0.000167	0	0.003685	8.6E-06	0.000132
'3004	-0.00356	-0.00352	-0.00368	0	-0.00368	-0.00355
'3003	0.000117	0.000159	-8.6E-06	0.003676	0	0.000123
'3002	-6.5E-06	3.54E-05	-0.00013	0.003553	-0.00012	0
Morocco cross-commodity comparison					Value in 2015	
Product code	'3006	'3005	'3001	'3004	'3003	'3002
'3006	0	2.74E-05	-0.00023	0.004777	2.68E-05	-6.3E-05
'3005	-2.7E-05	0	-0.00026	0.00475	-6.4E-07	-9E-05
'3001	0.000229	0.000256	0	0.005006	0.000255	0.000166
'3004	-0.00478	-0.00475	-0.00501	0	-0.00475	-0.00484
'3003	-2.7E-05	6.4E-07	-0.00026	0.004751	0	-9E-05
'3002	6.28E-05	9.02E-05	-0.00017	0.00484	8.96E-05	0
Morocco cross-commodity comparison					Value in 2020	
Product code	'3006	'3005	'3001	'3004	'3003	'3002
'3006	0	0.000333	-2.8E-05	0.005556	-1.7E-05	0.000312
'3005	-0.00033	0	-0.00036	0.005223	-0.00035	-2.1E-05
'3001	2.83E-05	0.000361	0	0.005584	1.15E-05	0.000341
'3004	-0.00556	-0.00522	-0.00558	0	-0.00557	-0.00524
'3003	1.67E-05	0.00035	-1.2E-05	0.005573	0	0.000329
'3002	-0.00031	2.05E-05	-0.00034	0.005243	-0.00033	0

Table 36: Algeria cross-commodity NRCA results

Algeria cross-commodity comparison					Value in 2001	
Product code	**'3006**	**'3005**	**'3001**	**'3004**	**'3003**	**'3002**
'3006	0	1.48E-05	1.65E-06	9.01E-06	1.14E-07	2.95E-06
'3005	-1.5E-05	0	-1.3E-05	-5.8E-06	-1.5E-05	-1.2E-05
'3001	-1.6E-06	1.31E-05	0	7.37E-06	-1.5E-06	1.3E-06
'3004	-9E-06	5.76E-06	-7.4E-06	0	-8.9E-06	-6.1E-06
'3003	-1.1E-07	1.47E-05	1.53E-06	8.9E-06	0	2.84E-06
'3002	-3E-06	1.18E-05	-1.3E-06	6.06E-06	-2.8E-06	0
Algeria cross-commodity comparison					**Value in 2005**	
Product code	**'3006**	**'3005**	**'3001**	**'3004**	**'3003**	**'3002**
'3006	0	3.59E-06	2.29E-06	-1.9E-05	2.24E-05	-4.6E-06
'3005	-3.6E-06	0	-1.3E-06	-2.3E-05	1.88E-05	-8.2E-06
'3001	-2.3E-06	1.3E-06	0	-2.2E-05	2.01E-05	-6.9E-06
'3004	1.93E-05	2.29E-05	2.16E-05	0	4.17E-05	1.47E-05
'3003	-2.2E-05	-1.9E-05	-2E-05	-4.2E-05	0	-2.7E-05
'3002	4.62E-06	8.21E-06	6.91E-06	-1.5E-05	2.7E-05	0
Algeria cross-commodity comparison					**Value in 2010**	
Product code	**'3006**	**'3005**	**'3001**	**'3004**	**'3003**	**'3002**
'3006	0	5.09E-07	7.97E-07	1.16E-05	-6.3E-07	-1.8E-05
'3005	-5.1E-07	0	2.87E-07	1.11E-05	-1.1E-06	-1.8E-05
'3001	-8E-07	-2.9E-07	0	1.08E-05	-1.4E-06	-1.9E-05
'3004	-1.2E-05	-1.1E-05	-1.1E-05	0	-1.2E-05	-3E-05
'3003	6.33E-07	1.14E-06	1.43E-06	1.23E-05	0	-1.7E-05
'3002	1.8E-05	1.85E-05	1.88E-05	2.96E-05	1.73E-05	0
Algeria cross-commodity comparison					**Value in 2015**	
Product code	**'3006**	**'3005**	**'3001**	**'3004**	**'3003**	**'3002**
'3006	0	-6.3E-06	-6E-06	9.36E-05	-6.9E-06	-1.7E-05
'3005	6.34E-06	0	3.26E-07	9.99E-05	-5.4E-07	-1.1E-05

'3001	6.02E-06	-3.3E-07	0	9.96E-05	-8.7E-07	-1.1E-05
'3004	-9.4E-05	-1E-04	-1E-04	0	-0.0001	-0.00011
'3003	6.89E-06	5.43E-07	8.69E-07	0.0001	0	-1E-05
'3002	1.72E-05	1.08E-05	1.11E-05	0.000111	1.03E-05	0
Algeria cross-commodity comparison					**Value in 2020**	
Product code	**'3006**	**'3005**	**'3001**	**'3004**	**'3003**	**'3002**
'3006	0	1.02E-06	7.92E-07	-2.8E-05	4.09E-07	-1.6E-05
'3005	-1E-06	0	-2.3E-07	-2.9E-05	-6.1E-07	-1.7E-05
'3001	-7.9E-07	2.29E-07	0	-2.9E-05	-3.8E-07	-1.6E-05
'3004	2.77E-05	2.88E-05	2.85E-05	0	2.81E-05	1.21E-05
'3003	-4.1E-07	6.12E-07	3.83E-07	-2.8E-05	0	-1.6E-05
'3002	1.56E-05	1.66E-05	1.64E-05	-1.2E-05	1.6E-05	0

Table 37: Tunisia

Tunisia cross-commodity comparison					**Value in 2001**	
Product code	**'3006**	**'3005**	**'3001**	**'3004**	**'3003**	**'3002**
'3006	0	-0.00065	-0.00064	-0.00078	-0.00061	-0.00076
'3005	0.000646	0	8.1E-06	-0.00013	3.34E-05	-0.00012
'3001	0.000638	-8.1E-06	0	-0.00014	2.53E-05	-0.00013
'3004	0.000777	0.000132	0.00014	0	0.000165	1.45E-05
'3003	0.000612	-3.3E-05	-2.5E-05	-0.00017	0	-0.00015
'3002	0.000763	0.000117	0.000125	-1.4E-05	0.000151	0
Tunisia cross-commodity comparison					**Value in 2005**	
Product code	**'3006**	**'3005**	**'3001**	**'3004**	**'3003**	**'3002**
'3006	0	-0.00078	-0.00051	-0.00088	-0.00085	-0.00086
'3005	0.000776	0	0.000266	-9.9E-05	-7.3E-05	-8.3E-05
'3001	0.000509	-0.00027	0	-0.00037	-0.00034	-0.00035
'3004	0.000875	9.95E-05	0.000366	0	2.6E-05	1.68E-05
'3003	0.000849	7.35E-05	0.00034	-2.6E-05	0	-9.2E-06

'3002	0.000858	8.27E-05	0.000349	-1.7E-05	9.21E-06	0

Tunisia cross-commodity comparison					**Value in 2010**	
Product code	**'3006**	**'3005**	**'3001**	**'3004**	**'3003**	**'3002**
'3006	0	-0.00139	-0.00125	-0.00148	-0.00146	-0.00145
'3005	0.001388	0	0.000133	-9.6E-05	-7.6E-05	-6.1E-05
'3001	0.001254	-0.00013	0	-0.00023	-0.00021	-0.00019
'3004	0.001484	9.64E-05	0.00023	0	1.99E-05	3.57E-05
'3003	0.001464	7.65E-05	0.00021	-2E-05	0	1.58E-05
'3002	0.001448	6.07E-05	0.000194	-3.6E-05	-1.6E-05	0

Tunisia cross-commodity comparison					**Value in 2015**	
Product code	**'3006**	**'3005**	**'3001**	**'3004**	**'3003**	**'3002**
'3006	0	-0.00199	-0.00213	-0.00234	-0.00226	-0.00233
'3005	0.001986	0	-0.00015	-0.00035	-0.00028	-0.00034
'3001	0.002133	0.000147	0	-0.00021	-0.00013	-0.0002
'3004	0.002338	0.000352	0.000205	0	7.63E-05	1.04E-05
'3003	0.002262	0.000276	0.000129	-7.6E-05	0	-6.6E-05
'3002	0.002328	0.000342	0.000195	-1E-05	6.59E-05	0

Tunisia cross-commodity comparison					**Value in 2020**	
Product code	**'3006**	**'3005**	**'3001**	**'3004**	**'3003**	**'3002**
'3006	0	-1.3E-06	-1.2E-06	-2E-05	-1.4E-06	-1.1E-05
'3005	1.26E-06	0	6.06E-08	-1.9E-05	-1.5E-07	-1E-05
'3001	1.2E-06	-6.1E-08	0	-1.9E-05	-2.1E-07	-1E-05
'3004	1.99E-05	1.86E-05	1.87E-05	0	1.85E-05	8.42E-06
'3003	1.41E-06	1.48E-07	2.08E-07	-1.8E-05	0	-1E-05
'3002	1.15E-05	1.02E-05	1.03E-05	-8.4E-06	1.01E-05	0

Table 38: Kenya cross-commodity NRCA results

Kenya cross-commodity comparison					Value in 2001	
Product code	**'3006**	**'3005**	**'3001**	**'3004**	**'3003**	**'3002**
'3006	0	6.44E-08	1.35E-07	-3.6E-06	1.27E-08	-3.2E-07
'3005	-6.4E-08	0	7.01E-08	-3.7E-06	-5.2E-08	-3.8E-07
'3001	-1.3E-07	-7E-08	0	-3.8E-06	-1.2E-07	-4.5E-07
'3004	3.65E-06	3.71E-06	3.78E-06	0	3.66E-06	3.33E-06
'3003	-1.3E-08	5.18E-08	1.22E-07	-3.7E-06	0	-3.3E-07
'3002	3.17E-07	3.82E-07	4.52E-07	-3.3E-06	3.3E-07	0
Kenya cross-commodity comparison					**Value in 2005**	
Product code	**'3006**	**'3005**	**'3001**	**'3004**	**'3003**	**'3002**
'3006	0	1.64E-07	1.47E-07	-4E-06	3.18E-07	-6.5E-07
'3005	-1.6E-07	0	-1.6E-08	-4.2E-06	1.55E-07	-8.1E-07
'3001	-1.5E-07	1.64E-08	0	-4.2E-06	1.71E-07	-7.9E-07
'3004	4.01E-06	4.17E-06	4.16E-06	0	4.33E-06	3.36E-06
'3003	-3.2E-07	-1.5E-07	-1.7E-07	-4.3E-06	0	-9.7E-07
'3002	6.47E-07	8.11E-07	7.94E-07	-3.4E-06	9.66E-07	0
Kenya cross-commodity comparison					**Value in 2010**	
Product code	**'3006**	**'3005**	**'3001**	**'3004**	**'3003**	**'3002**
'3006	0	1.9E-07	1.18E-07	-3.1E-06	3.94E-07	-1.2E-06
'3005	-1.9E-07	0	-7.2E-08	-3.3E-06	2.04E-07	-1.4E-06
'3001	-1.2E-07	7.18E-08	0	-3.2E-06	2.76E-07	-1.3E-06
'3004	3.12E-06	3.31E-06	3.24E-06	0	3.52E-06	1.96E-06
'3003	-3.9E-07	-2E-07	-2.8E-07	-3.5E-06	0	-1.6E-06
'3002	1.16E-06	1.35E-06	1.28E-06	-2E-06	1.56E-06	0
Kenya cross-commodity comparison					**Value in 2015**	
Product code	**'3006**	**'3005**	**'3001**	**'3004**	**'3003**	**'3002**
'3006	0	9.74E-08	8.53E-08	1.77E-07	1.76E-07	-2E-06
'3005	-9.7E-08	0	-1.2E-08	8E-08	7.87E-08	-2.1E-06

'3001	-8.5E-08	1.21E-08	0	9.21E-08	9.08E-08	-2.1E-06
'3004	-1.8E-07	-8E-08	-9.2E-08	0	-1.3E-09	-2.2E-06
'3003	-1.8E-07	-7.9E-08	-9.1E-08	1.32E-09	0	-2.2E-06
'3002	2.04E-06	2.14E-06	2.13E-06	2.22E-06	2.22E-06	0

Kenya cross-commodity comparison					**Value in 2020**	
Product code	**'3006**	**'3005**	**'3001**	**'3004**	**'3003**	**'3002**
'3006	0	1.34E-07	1.72E-07	-1.7E-06	1.69E-07	-4E-06
'3005	-1.3E-07	0	3.86E-08	-1.9E-06	3.56E-08	-4.1E-06
'3001	-1.7E-07	-3.9E-08	0	-1.9E-06	-3E-09	-4.1E-06
'3004	1.72E-06	1.86E-06	1.9E-06	0	1.89E-06	-2.2E-06
'3003	-1.7E-07	-3.6E-08	3E-09	-1.9E-06	0	-4.1E-06
'3002	3.95E-06	4.09E-06	4.13E-06	2.23E-06	4.12E-06	0

**Positive values in red show a comparative advantage, negative values show a comparative disadvantage.

Appendix K: A cross-country comparison of African countries

Table 39: South Africa cross-country

SA cross-country comparison																Value in 2001	
Country	Nigeria	Egypt	Morocco	Algeria	Tunisia	Kenya	Switzerland	Brazil	Belgium	Netherlands	France	Italy	China	India	Germany	SA	USA
'3006	-2.85E-07	-1.4E-05	-5.5E-05	-2.1E-07	-0.00076	-2.1E-06	-0.02802	1.35E-06	1.53E-05	-0.0009	-2.5E-05	-0.01721	-1.7E-05	8.5E-07	-0.000123	0	-2.2E-05
'3005	3.839E-07	-0.0004	-9.4E-05	-1.4E-05	-0.00012	-7.3E-07	-0.006574	2.64E-06	-5.2E-06	-0.00185	-0.05483	-0.00505	1.3E-05	3.9E-07	-4.53E-06	0	-1.4E-05
'3001	-1.5E-07	-4.4E-07	-3.8E-07	-1.3E-07	-0.00012	-5E-07	-0.003595	-6.3E-06	3.5E-06	-1.4E-05	-0.16523	-0.00352	-4.1E-05	-1E-06	5.32E-06	0	-1.6E-05
'3004	-1.38E-05	-0.00648	-0.00227	-6.6E-05	-4.2E-05	-5.5E-05	-13.86718	8.48E-05	0.000408	-0.00569	-0.01947	-0.93675	0.00061	-7E-05	-0.000782	0	0.000378
'3003	1.011E-06	-0.0011	-2.3E-06	1.17E-06	-0.00015	-6.2E-07	-0.015455	4.63E-06	1.81E-05	-0.00057	-0.03118	-0.01825	2E-05	-3E-05	1.07E-05	0	4.24E-06
'3002	-9.43E-07	-5.2E-05	-0.00014	-7.6E-06	-4.6E-06	-6.2E-06	-0.336371	-1.5E-05	5.39E-05	-0.00153	-0.01894	-0.05438	5.8E-05	-2E-06	-0.000112	0	-0.00016
SA cross-country comparison																Value in 2005	
Country	Nigeria	Egypt	Morocco	Algeria	Tunisia	Kenya	Switzerland	Brazil	Belgium	Netherlands	France	Italy	China	India	Germany	SA	USA
'3006	-2.89E-06	-5.4E-06	-0.00011	2.94E-07	-0.00086	-2.7E-06	-0.033753	2.38E-06	2.08E-05	-0.00088	-1.2E-05	-0.01182	7.8E-06	2.3E-06	-0.000136	0	-1.1E-05
'3005	-8.19E-07	-0.00016	-0.00018	-1.2E-06	-8.1E-05	-7.8E-07	-0.008988	3.29E-06	1.14E-05	-0.003	-0.03089	-0.0049	1.9E-05	8.9E-07	-2.42E-06	0	-9.4E-06
'3001	-8.94E-07	-6.9E-07	-5.5E-06	-4.2E-09	-0.00035	-8.4E-07	-0.00132	-3.5E-06	5.6E-06	-9.1E-06	-0.17907	-0.00324	-3.7E-05	-3E-07	1.29E-05	0	-4E-05
'3004	-8.19E-05	-0.00574	-0.00235	-5.9E-05	-6.2E-05	-7.8E-05	-1.55389	0.000139	0.000528	-0.00548	-0.01658	-1.02214	0.00134	-9E-05	-0.001014	0	0.000315
'3003	4.263E-07	-0.00023	-1.3E-05	-1.9E-05	-6E-06	3.1E-07	-0.038457	6.16E-07	1.87E-05	-0.00041	-0.03983	-0.02266	3.7E-05	-1E-05	1.12E-05	0	-7E-05
'3002	-1.14E-05	-0.00023	-9E-05	-3.6E-06	-8.6E-06	-1.1E-05	-0.533283	-9.4E-06	7.89E-05	-0.00116	-0.02563	-0.06496	0.00017	8.5E-06	-0.000207	0	-0.00029

SA cross-country comparison																Value in 2010	
Country	Nigeria	Egypt	Morocco	Algeria	Tunisia	Kenya	Switzerland	Brazil	Belgium	Netherlands	France	Italy	China	India	Germany	SA	USA
'3006	-2.36E-05	-7E-06	-0.00013	-1.3E-07	-0.00147	-2E-06	-0.047323	6.25E-06	2.29E-05	-0.00094	-1E-05	-0.02035	1.8E-05	6.9E-06	-0.000151	0	-1.3E-05
'3005	1.075E-06	-0.00019	-0.00017	2.66E-07	-7.7E-05	-1.3E-06	-0.004065	3.4E-06	8.84E-06	-0.00147	-0.02434	-0.0059	1.5E-05	1.5E-06	-1.64E-05	0	-3E-06
'3001	-5.59E-05	-1.2E-06	-1.4E-06	-5.2E-07	-0.00021	-1.7E-06	-0.000411	-9.2E-06	7.31E-06	-4.1E-05	-0.31089	-0.00654	-2.9E-05	2.3E-06	6.45E-06	0	-5.4E-05
'3004	3.002E-06	-0.01531	-0.00378	-0.0001	-7.3E-05	-9.1E-05	-1.829342	0.000174	0.000431	-0.01731	-0.00992	-0.92883	0.00203	-0.0001	-0.001205	0	0.000106
'3003	-0.000224	-0.00091	-1.1E-05	2.37E-07	-1.7E-06	-2.6E-06	-0.013609	1.67E-06	1.7E-05	-0.00287	-0.03965	-0.02214	5.1E-05	-3E-05	2.64E-05	0	-5.1E-05
'3002	1.103E-06	-3.2E-05	-0.00016	-6.6E-06	-4.2E-05	-2.5E-05	-1.098106	-1.6E-05	0.000116	-0.00221	-0.03617	-0.09928	0.00043	3.7E-05	-0.000639	0	-0.00043
SA cross-country comparison																Value in 2015	
Country	Nigeria	Egypt	Morocco	Algeria	Tunisia	Kenya	Switzerland	Brazil	Belgium	Netherlands	France	Italy	China	India	Germany	SA	USA
'3006	8.184E-07	-7.9E-06	-0.00023	-7.2E-06	-0.00232	-1.6E-06	-0.045512	4.37E-06	1.97E-05	-0.07097	-4.3E-06	-0.02119	-5E-05	7.2E-07	-0.000113	0	-2E-05
'3005	-6.27E-07	-0.00256	-0.00026	-6.8E-07	-0.00034	-1.5E-06	-0.003595	2.9E-06	8.79E-06	-0.0156	-0.04933	-0.00632	7.1E-06	2.4E-06	-1.54E-05	0	-6.6E-06
'3001	-2.45E-06	-9.5E-07	-9.4E-07	-7.4E-07	-0.00019	-1.2E-06	-0.002533	-7.7E-06	4.79E-06	-0.01099	-0.30796	-0.00458	-4.6E-05	3.6E-07	1.55E-05	0	-5.1E-05
'3004	-0.000108	-0.01166	-0.00509	-0.00018	-6.3E-05	-8E-05	-2.087645	0.000145	0.00036	-0.02171	-0.00103	-0.99772	0.00261	-0.0005	-0.001475	0	0.000212
'3003	-3.47E-05	-0.0012	-0.00026	-2.5E-07	-6.1E-05	-1.7E-06	-0.015321	8.3E-07	1.47E-05	-0.02216	-0.0293	-0.02717	5.6E-05	-1E-05	3.12E-05	0	-2.1E-05
'3002	-1.27E-05	-3.6E-05	-0.0002	-2.3E-05	-2.8E-05	-3.2E-05	-1.507511	-8.1E-06	0.000143	-0.09874	-0.03493	-0.14831	0.00093	4.2E-05	-0.000755	0	-0.00043
SA cross-country comparison																Value in 2020	
Country	Nigeria	Egypt	Morocco	Algeria	Tunisia	Kenya	Switzerland	Brazil	Belgium	Netherlands	France	Italy	China	India	Germany	SA	USA
'3006	-1.11E-06	-0.00014	-3.1E-05	-1.7E-06	-3.8E-06	-2.6E-06	-0.037195	1.84E-06	-0.0686	-0.05699	-7.6E-06	-0.03399	-0.00012	-2E-06	-0.000101	0	-3E-05
'3005	-8.65E-07	-0.00262	-0.00036	-1.7E-06	-1.5E-06	-1.7E-06	-0.002618	3.86E-06	-0.008	-0.02262	-0.022	-0.01135	1.3E-05	2.6E-06	-9.79E-06	0	-7.9E-06
'3001	-8.29E-07	-3.5E-05	-1.2E-06	-1.1E-06	-1.2E-06	-1.3E-06	-0.000877	-4E-06	-0.00062	-0.01458	-0.46885	-0.0075	-6.6E-05	-9E-07	6.24E-06	0	-1.3E-05
'3004	-6.54E-05	-0.01233	-0.00568	-7E-05	-8E-05	-9.7E-05	-2.741354	0.000178	-1.37543	-1.12514	-0.01577	-1.55686	0.00317	-0.0007	-0.001727	0	0.00048
'3003	-1.66E-05	-0.00032	-1.3E-05	-6E-07	-8.8E-07	-1.2E-06	-0.044142	1.8E-06	-0.01437	-0.02404	-0.02941	-0.01905	3.3E-05	-1E-05	4.44E-06	0	-4.9E-05
'3002	-3.77E-05	-0.00019	-0.0004	-4.7E-05	-5.3E-05	-5.9E-05	-2.288987	5.74E-05	-1.1855	-0.39691	-0.03466	-0.45601	0.00187	8.8E-05	-0.000837	0	-0.00046

**Positive values in red show a comparative advantage, negative values show a comparative disadvantage

Table 40: Nigeria cross-country

Nigeria cross-country comparison																Value in 2001
Country	Nigeria	Egypt	Morocco	Algeria	Tunisia	Kenya	Switzerland	Brazil	Belgium	Netherlands	France	Italy	China	India	Germany	SA	USA
'3006	0	-1.4E-05	-5.4E-05	7.56E-08	-0.00076	-1.8E-06	-0.02802	1.63E-06	1.56E-05	-0.0009	-2.5E-05	-0.01721	-1.6E-05	1.1319E-06	-0.0001226	2.8482E-07	-2.2E-05
'3005	0	-0.0004	-9.5E-05	-1.4E-05	-0.00012	-1.1E-06	-0.00657	2.26E-06	-5.6E-06	-0.00185	-0.05483	-0.00505	1.27E-05	5.0222E-09	-4.91E-06	-3.839E-07	-1.4E-05
'3001	0	-2.9E-07	-2.3E-07	2.33E-08	-0.00012	-3.5E-07	-0.0036	-6.1E-06	3.65E-06	-1.4E-05	-0.16523	-0.00352	-4.1E-05	-8.073E-07	5.4674E-06	1.499E-07	-1.5E-05
'3004	0	-0.00647	-0.00225	-5.2E-05	-2.9E-05	-4.1E-05	-13.8672	9.85E-05	0.000422	-0.00568	-0.01945	-0.93673	0.000621	-5.987E-05	-0.000768	1.3766E-05	0.000391
'3003	0	-0.0011	-3.3E-06	1.58E-07	-0.00015	-1.6E-06	-0.01546	3.62E-06	1.71E-05	-0.00057	-0.03118	-0.01825	1.89E-05	-2.922E-05	9.6633E-06	-1.011E-06	3.23E-06
'3002	0	-5.1E-05	-0.00014	-6.6E-06	-3.6E-06	-5.3E-06	-0.33637	-1.4E-05	5.48E-05	-0.00153	-0.01894	-0.05438	5.92E-05	-1.356E-06	-0.0001114	9.4255E-07	-0.00015

Nigeria cross-country comparison																Value in 2005
Country	Nigeria	Egypt	Morocco	Algeria	Tunisia	Kenya	Switzerland	Brazil	Belgium	Netherlands	France	Italy	China	India	Germany	SA	USA
'3006	0	-2.6E-06	-0.0001	3.18E-06	-0.00086	1.99E-07	-0.03375	5.27E-06	2.37E-05	-0.00088	-9.1E-06	-0.01181	1.07E-05	5.2175E-06	-0.0001336	2.8896E-06	-8E-06
'3005	0	-0.00016	-0.00018	-4.1E-07	-8E-05	3.55E-08	-0.00899	4.11E-06	1.22E-05	-0.003	-0.03089	-0.0049	2.03E-05	1.7127E-06	-1.597E-06	8.1925E-07	-8.6E-06
'3001	0	2.06E-07	-4.6E-06	8.9E-07	-0.00035	5.19E-08	-0.00132	-2.6E-06	6.49E-06	-8.2E-06	-0.17907	-0.00324	-3.6E-05	6.2584E-07	1.379E-05	8.9436E-07	-3.9E-05
'3004	0	-0.00566	-0.00227	2.25E-05	1.96E-05	4.21E-06	-1.55381	0.000221	0.00061	-0.0054	-0.0165	-1.02206	0.001425	-6.561E-06	-0.0009322	8.194E-05	0.000397

'3003	0	-0.00023	-1.4E-05	-1.9E-05	-6.4E-06	-1.2E-07	-0.03846	1.9E-07	1.83E-05	-0.00041	-0.03983	-0.02266	3.7E-05	-1.455E-05	1.077E-05	-4.263E-07	-7.1E-05
'3002	0	-0.00022	-7.9E-05	7.8E-06	2.82E-06	8.46E-07	-0.53327	2.01E-06	9.03E-05	-0.00115	-0.02562	-0.06495	0.000182	1.9894E-05	-0.0001958	1.1403E-05	-0.00028

Nigeria cross-country comparison															**Value in 2010**	
Country	**Nigeria**	**Egypt**	**Morocco**	**Algeria**	**Tunisia**	**Kenya**	**Switzerland**	**Brazil**	**Belgium**	**Netherlands**	**France**	**Italy**	**China**	**India**	**Germany**	**SA**	**USA**
'3006	**0**	1.66E-05	-0.0001	2.35E-05	-0.00144	2.17E-05	-0.0473	2.99E-05	4.65E-05	-0.00091	1.33E-05	-0.02033	4.19E-05	3.0558E-05	-0.0001276	2.3634E-05	1.05E-05
'3005	**0**	-0.00019	-0.00017	-8.1E-07	-7.8E-05	-2.3E-06	-0.00407	2.33E-06	7.76E-06	-0.00147	-0.02434	-0.0059	1.34E-05	4.3375E-07	-1.747E-05	-1.075E-06	-4.1E-06
'3001	**0**	5.47E-05	5.45E-05	5.54E-05	-0.00015	5.42E-05	-0.00035	4.67E-05	6.32E-05	1.49E-05	-0.31083	-0.00648	2.64E-05	5.8226E-05	6.2339E-05	5.5886E-05	1.45E-06
'3004	**0**	-0.01531	-0.00378	-0.00011	-7.6E-05	-9.4E-05	-1.82934	0.000171	0.000428	-0.01732	-0.00992	-0.92884	0.002028	-0.0001399	-0.0012079	-3.002E-06	0.000103
'3003	**0**	-0.00069	0.000213	0.000224	0.000222	0.000221	-0.01339	0.000225	0.000241	-0.00264	-0.03943	-0.02192	0.000275	0.0001908	0.00024996	0.00022354	0.000173
'3002	**0**	-3.3E-05	-0.00016	-7.7E-06	-4.3E-05	-2.6E-05	-1.09811	-1.7E-05	0.000115	-0.00221	-0.03617	-0.09928	0.000429	3.632E-05	-0.0006399	-1.103E-06	-0.00044

Nigeria cross-country comparison															**Value in 2015**	
Country	**Nigeria**	**Egypt**	**Morocco**	**Algeria**	**Tunisia**	**Kenya**	**Switzerland**	**Brazil**	**Belgium**	**Netherlands**	**France**	**Italy**	**China**	**India**	**Germany**	**SA**	**USA**

'3006	0	-8.7E-06	-0.00023	-8E-06	-0.00232	-2.4E-06	-0.04551	3.55E-06	1.89E-05	-0.07097	-5.1E-06	-0.02119	-5.1E-05	-9.538E-08	-0.0001143	-8.184E-07	-2.1E-05
'3005	0	-0.00256	-0.00026	-5.1E-08	-0.00034	-8.6E-07	-0.00359	3.52E-06	9.41E-06	-0.0156	-0.04933	-0.00632	7.74E-06	3.0216E-06	-1.474E-05	6.2741E-07	-6E-06
'3001	0	1.5E-06	1.51E-06	1.71E-06	-0.00019	1.25E-06	-0.00253	-5.2E-06	7.24E-06	-0.01098	-0.30795	-0.00458	-4.3E-05	2.8066E-06	1.7955E-05	2.4492E-06	-4.8E-05
'3004	0	-0.01156	-0.00498	-7.1E-05	4.44E-05	2.77E-05	-2.08754	0.000253	0.000468	-0.0216	-0.00092	-0.99761	0.002714	-0.0003432	-0.0013675	0.00010752	0.000319
'3003	0	-0.00116	-0.00022	3.45E-05	-2.7E-05	3.31E-05	-0.01529	3.56E-05	4.95E-05	-0.02213	-0.02926	-0.02714	9.05E-05	2.3963E-05	6.5918E-05	3.4744E-05	1.35E-05
'3002	0	-2.4E-05	-0.00019	-1E-05	-1.5E-05	-2E-05	-1.5075	4.61E-06	0.000156	-0.09873	-0.03492	-0.1483	0.000946	5.4413E-05	-0.0007419	-1.2728E-05	-0.00042

Nigeria cross-country comparison

Value in 2020

Country	**Nigeria**	**Egypt**	**Morocco**	**Algeria**	**Tunisia**	**Kenya**	**Switzerland**	**Brazil**	**Belgium**	**Netherlands**	**France**	**Italy**	**China**	**India**	**Germany**	**SA**	**USA**
'3006	0	-0.00014	-3E-05	-6.2E-07	-2.7E-06	-1.5E-06	-0.03719	2.95E-06	-0.0686	-0.05698	-6.5E-06	-0.03399	-0.00012	-8.051E-07	-0.0001001	1.1088E-06	-2.9E-05
'3005	0	-0.00262	-0.00036	-8.4E-07	-6.5E-07	-7.9E-07	-0.00262	4.72E-06	-0.008	-0.02262	-0.022	-0.01135	1.38E-05	3.4322E-06	-8.923E-06	8.6525E-07	-7E-06

'3001	0	-3.4E-05	-4E-07	-2.3E-07	-3.4E-07	-4.5E-07	-0.00088	-3.1E-06	-0.00062	-0.01458	-0.46885	-0.0075	-6.5E-05	-7.35E-08	7.0686E-06	8.2868E-07	-1.2E-05
'3004	0	-0.01226	-0.00562	-5.1E-06	-1.5E-05	-3.2E-05	-2.74129	0.000243	-1.37537	-1.12507	-0.0157	-1.5568	0.003236	-0.0006267	-0.0016617	6.5363E-05	0.000545
'3003	0	-0.0003	3.96E-06	1.6E-05	1.57E-05	1.54E-05	-0.04413	1.84E-05	-0.01435	-0.02403	-0.02939	-0.01903	4.94E-05	4.7977E-06	2.1065E-05	1.6624E-05	-3.3E-05
'3002	0	-0.00015	-0.00037	-9.3E-06	-1.6E-05	-2.2E-05	-2.28895	9.51E-05	-1.18546	-0.39688	-0.03462	-0.45597	0.001905	0.00012523	-0.0007991	3.7706E-05	-0.00043

Table 41: Egypt cross-country

Egypt cross-country comparison															**Value in 2001**	
Country	**Nigeria**	**Egypt**	**Morocco**	**Algeria**	**Tunisia**	**Kenya**	**Switzerland**	**Brazil**	**Belgium**	**Netherlands**	**France**	**Italy**	**China**	**India**	**Germany**	**SA**	**USA**
'3006	1.39E-05	0	-4.1E-05	1.4E-05	-0.00075	1.21E-05	-0.02801	1.55E-05	2.95E-05	-0.00088	-1.1E-05	-0.01719	-2.3E-06	1.51E-05	-0.00011	1.42E-05	-8.1E-06
'3005	0.000396	0	0.000302	0.000383	0.00028	0.000395	-0.00618	0.000399	0.000391	-0.00145	-0.05443	-0.00465	0.000409	0.000396	0.000392	0.000396	0.000382
'3001	2.94E-07	0	6.36E-08	3.18E-07	-0.00012	-5.5E-08	-0.00359	-5.8E-06	3.94E-06	-1.4E-05	-0.16523	-0.00352	-4.1E-05	-5.1E-07	5.76E-06	4.44E-07	-1.5E-05
'3004	0.006467	0	0.004215	0.006415	0.006438	0.006426	-13.8607	0.006566	0.006889	0.000789	-0.01299	-0.93027	0.007089	0.006407	0.005699	0.006481	0.006858
'3003	0.001098	0	0.001095	0.001099	0.000948	0.001097	-0.01436	0.001102	0.001115	0.000531	-0.03008	-0.01716	0.001117	0.001069	0.001108	0.001097	0.001102
'3002	5.07E-05	0	-9.1E-05	4.41E-05	4.71E-05	4.55E-05	-0.33632	3.64E-05	0.000106	-0.00147	-0.01889	-0.05433	0.00011	4.94E-05	-6.1E-05	5.17E-05	-0.0001

Egypt cross-country comparison																Value in 2005	
Country	Nigeria	Egypt	Morocco	Algeria	Tunisia	Kenya	Switzerland	Brazil	Belgium	Netherlands	France	Italy	China	India	Germany	SA	USA
'3006	2.55E-06	0	-0.0001	5.74E-06	-0.00085	2.75E-06	-0.03375	7.82E-06	2.63E-05	-0.00088	-6.6E-06	-0.01181	1.32E-05	7.77E-06	-0.00013	5.44E-06	-5.5E-06
'3005	0.000157	0	-2.3E-05	0.000156	7.67E-05	0.000157	-0.00883	0.000161	0.000169	-0.00284	-0.03073	-0.00475	0.000177	0.000158	0.000155	0.000157	0.000148
'3001	-2.1E-07	0	-4.8E-06	6.84E-07	-0.00035	-1.5E-07	-0.00132	-2.8E-06	6.29E-06	-8.4E-06	-0.17907	-0.00324	-3.6E-05	4.2E-07	1.36E-05	6.88E-07	-4E-05
'3004	0.005663	0	0.00339	0.005685	0.005682	0.005667	-1.54815	0.005883	0.006273	0.000267	-0.01084	-1.0164	0.007087	0.005656	0.00473	0.005745	0.00606
'3003	0.00023	0	0.000217	0.000211	0.000224	0.00023	-0.03823	0.000231	0.000249	-0.00018	-0.0396	-0.02243	0.000267	0.000216	0.000241	0.00023	0.00016
'3002	0.000219	0	0.00014	0.000227	0.000222	0.00022	-0.53305	0.000221	0.000309	-0.00093	-0.0254	-0.06473	0.0004	0.000239	2.29E-05	0.00023	-5.8E-05

Egypt cross-country comparison																Value in 2010	
Country	**Nigeria**	**Egypt**	**Morocco**	**Algeria**	**Tunisia**	**Kenya**	**Switzerland**	**Brazil**	**Belgium**	**Netherlands**	**France**	**Italy**	**China**	**India**	**Germany**	**SA**	**USA**
'3006	-1.7E-05	0	-0.00012	6.92E-06	-0.00146	5.08E-06	-0.04732	1.33E-05	2.99E-05	-0.00093	-3.3E-06	-0.02034	2.53E-05	1.4E-05	-0.00014	7.05E-06	-6E-06
'3005	0.000193	0	2.44E-05	0.000193	0.000115	0.000191	-0.00387	0.000196	0.000201	-0.00128	-0.02414	-0.00571	0.000207	0.000194	0.000176	0.000192	0.000189
'3001	-5.5E-05	0	-1.9E-07	6.87E-07	-0.00021	-4.7E-07	-0.00041	-8E-06	8.52E-06	-4E-05	-0.31088	-0.00654	-2.8E-05	3.55E-06	7.66E-06	1.21E-06	-5.3E-05
'3004	0.01531	0	0.011528	0.015203	0.015233	0.015216	-1.81404	0.015481	0.015738	-0.00201	0.005386	-0.91353	0.017338	0.01517	0.014102	0.015307	0.015413
'3003	0.000687	0	0.0009	0.000911	0.000909	0.000908	-0.0127	0.000912	0.000927	-0.00196	-0.03874	-0.02123	0.000961	0.000878	0.000937	0.00091	0.00086
'3002	3.34E-05	0	-0.00013	2.57E-05	-9.3E-06	7.06E-06	-1.09807	1.66E-05	0.000149	-0.00218	-0.03614	-0.09925	0.000462	6.98E-05	-0.00061	3.23E-05	-0.0004

Egypt cross-country comparison															Value in 2015	
Country	**Nigeria**	**Egypt**	**Morocco**	**Algeria**	**Tunisia**	**Kenya**	**Switzerland**	**Brazil**	**Belgium**	**Netherlands**	**France**	**Italy**	**China**	**India**	**Germany**	**SA**	**USA**
'3006	8.73E-06	0	-0.00022	6.79E-07	-0.00232	6.31E-06	-0.0455	1.23E-05	2.76E-05	-0.07096	3.59E-06	-0.02118	-4.3E-05	8.63E-06	-0.00011	7.91E-06	-1.2E-05
'3005	0.002564	0	0.002308	0.002564	0.002228	0.002563	-0.00103	0.002568	0.002574	-0.01303	-0.04676	-0.00376	0.002572	0.002567	0.002549	0.002565	0.002558
'3001	-1.5E-06	0	6.19E-09	2.1E-07	-0.00019	-2.6E-07	-0.00253	-6.7E-06	5.74E-06	-0.01099	-0.30796	-0.00458	-4.5E-05	1.3E-06	1.65E-05	9.47E-07	-5E-05
'3004	0.011557	0	0.006579	0.011486	0.011602	0.011585	-2.07598	0.01181	0.012025	-0.01004	0.010638	-0.98605	0.014271	0.011214	0.01019	0.011665	0.011876
'3003	0.001164	0	0.000942	0.001198	0.001137	0.001197	-0.01412	0.001199	0.001213	-0.02096	-0.0281	-0.02597	0.001254	0.001188	0.00123	0.001199	0.001177
'3002	2.37E-05	0	-0.00016	1.37E-05	8.29E-06	4.19E-06	-1.50747	2.83E-05	0.00018	-0.09871	-0.03489	-0.14827	0.00097	7.82E-05	-0.00072	3.65E-05	-0.0004

Egypt cross-country comparison															Value in 2020	
Country	**Nigeria**	**Egypt**	**Morocco**	**Algeria**	**Tunisia**	**Kenya**	**Switzerland**	**Brazil**	**Belgium**	**Netherlands**	**France**	**Italy**	**China**	**India**	**Germany**	**SA**	**USA**
'3006	0.000137	0	0.000107	0.000137	0.000135	0.000136	-0.03706	0.00014	-0.06846	-0.05685	0.000131	-0.03385	2.17E-05	0.000136	3.72E-05	0.000138	0.000108
'3005	0.002616	0	0.002254	0.002615	0.002616	0.002615	-1.1E-06	0.002621	-0.00538	-0.02001	-0.01938	-0.00874	0.00263	0.00262	0.002607	0.002617	0.002609

001	3.39E-05	0	3.35E-05	3.37E-05	3.36E-05	3.35E-05	-0.00084	3.08E-05	-0.00058	-0.01455	-0.46881	-0.00746	-3.2E-05	3.38E-05	4.1E-05	3.47E-05	2.21E-05
'3004	0.012261	0	0.006643	0.012256	0.012246	0.012229	-2.72903	0.012504	-1.36311	-1.11281	-0.00344	-1.54454	0.015497	0.011634	0.010599	0.012326	0.012806
'3003	0.000301	0	0.000305	0.000317	0.000317	0.000317	-0.04382	0.00032	-0.01405	-0.02373	-0.02909	-0.01873	0.000351	0.000306	0.000322	0.000318	0.000268
'3002	0.00015	0	-0.00022	0.000141	0.000135	0.000129	-2.2888	0.000245	-1.18531	-0.39673	-0.03447	-0.45582	0.002055	0.000276	-0.00065	0.000188	-0.00028

Table 42. Morocco cross-country

Morocco cross-country comparison																Value in 2001	
Country	Nigeria	Egypt	Morocco	Algeria	Tunisia	Kenya	Switzerland	Brazil	Belgium	Netherlands	France	Italy	China	India	Germany	SA	USA
'3006	5.45E-05	4.06E-05	0	5.46E-05	-0.00071	5.27E-05	-0.02797	5.61E-05	7.01E-05	-0.00084	2.94E-05	-0.01715	3.83E-05	5.5625E-05	-6.815E-05	5.48E-05	3.24E-05
'3005	9.47E-05	-0.0003	0	8.07E-05	-2.2E-05	9.35E-05	-0.00648	9.69E-05	8.91E-05	-0.00175	-0.05474	-0.00496	0.000107	9.4657E-05	8.974E-05	9.43E-05	8.03E-05
'3001	2.31E-07	-6.4E-08	0	2.54E-07	-0.00012	-1.2E-07	-0.00359	-5.9E-06	3.88E-06	-1.4E-05	-0.16523	-0.00352	-4.1E-05	-5.764E-07	5.698E-06	3.81E-07	-1.5E-05
'3004	0.002252	-0.00421	0	0.0022	0.002224	0.002211	-13.8649	0.002351	0.002674	-0.00343	-0.0172	-0.93448	0.002874	0.0021926 3	0.0014845	0.002266	0.002644
'3003	3.28E-06	-0.0011	0	3.44E-06	-0.00015	1.65E-06	-0.01545	6.91E-06	2.03E-05	-0.00056	-0.03118	-0.01825	2.22E-05	-2.594E-05	1.295E-05	2.27E-06	6.51E-06
'3002	0.000142	9.14E-05	0	0.000136	0.000139	0.000137	-0.33623	0.000128	0.000197	-0.00138	-0.0188	-0.05424	0.000201	0.0001407 9	3.07E-05	0.000143	-1.2E-05
Morocco cross-country comparison																Value in 2005	
Country	Nigeria	Egypt	Morocco	Algeria	Tunisia	Kenya	Switzerland	Brazil	Belgium	Netherlands	France	Italy	China	India	Germany	SA	USA

'3006	0.000105	0.000102	0	0.000108	-0.00075	0.000105	-0.03365	0.00011	0.000128	-0.00078	9.56E-05	-0.01171	0.000115	0.00010999	-2.881E-05	0.000108	9.67E-05
'3005	0.00018	2.34E-05	0	0.00018	0.0001	0.00018	-0.00881	0.000184	0.000192	-0.00282	-0.03071	-0.00472	0.0002	0.0001816 4	0.000178 3	0.000181	0.000171
'3001	4.6E-06	4.81E-06	0	5.49E-06	-0.00034	4.66E-06	-0.00131	2E-06	1.11E-05	-3.6E-06	-0.17907	-0.00324	-3.1E-05	5.2293E-06	1.839E-05	5.5E-06	-3.5E-05
'3004	0.002273	-0.00339	0	0.002295	0.002292	0.002277	-1.55154	0.002493	0.002883	-0.00312	-0.01423	-1.01979	0.003697	0.0022660 7	0.001340 4	0.002355	0.00267
'3003	1.35E-05	-0.00022	0	-5.7E-06	7.13E-06	1.34E-05	-0.03844	1.37E-05	3.18E-05	-0.0004	-0.03981	-0.02264	5.05E-05	-1.034E-06	2.428E-05	1.31E-05	-5.7E-05
'3002	7.91E-05	-0.00014	0	8.69E-05	8.19E-05	7.99E-05	-0.53319	8.11E-05	0.000169	-0.00107	-0.02554	-0.06487	0.000261	9.8963E-05	-0.000116 7	9.05E-05	-0.0002
Morocco cross-country comparison																**Value in 2010**	
Country	**Nigeria**	**Egypt**	**Morocco**	**Algeria**	**Tunisia**	**Kenya**	**Switzerland**	**Brazil**	**Belgium**	**Netherlands**	**France**	**Italy**	**China**	**India**	**Germany**	**SA**	**USA**
'3006	0.000103	0.00012	0	0.000127	-0.00134	0.000125	-0.0472	0.000133	0.00015	-0.00081	0.000117	-0.02022	0.000145	0.0001339 5	-2.425E-05	0.000127	0.000114
'3005	0.000169	-2.4E-05	0	0.000168	9.1E-05	0.000167	-0.0039	0.000171	0.000177	-0.0013	-0.02417	-0.00573	0.000183	0.0001695 2	0.000151 6	0.000168	0.000165
'3001	-5.4E-05	1.92E-07	0	8.79E-07	-0.00021	-2.8E-07	-0.00041	-7.8E-06	8.71E-06	-4E-05	-0.31088	-0.00654	-2.8E-05	3.74E-06	7.853E-06	1.4E-06	-5.3E-05

'3004	0.003781	-0.01153	0	0.003675	0.003705	0.003688	-1.82556	0.003952	0.00421	-0.01354	-0.00614	-0.92506	0.005809	0.00364121	0.0025733	0.003778	0.003885
'3003	-0.00021	-0.0009	0	1.09E-05	8.98E-06	8.04E-06	-0.0136	1.23E-05	2.77E-05	-0.00286	-0.03964	-0.02213	6.17E-05	-2.207E-05	3.709E-05	1.07E-05	-4E-05
'3002	0.000159	0.000126	0	0.000151	0.000116	0.000133	-1.09795	0.000142	0.000274	-0.00205	-0.03601	-0.09912	0.000588	0.00019541	-0.0004808	0.000158	-0.00028
Morocco cross-country comparison																**Value in 2015**	
Country	**Nigeria**	**Egypt**	**Morocco**	**Algeria**	**Tunisia**	**Kenya**	**Switzerland**	**Brazil**	**Belgium**	**Netherlands**	**France**	**Italy**	**China**	**India**	**Germany**	**SA**	**USA**
'3006	0.000231	0.000222	0	0.000223	-0.00209	0.000229	-0.04528	0.000234	0.00025	-0.07074	0.000226	-0.02096	0.00018	0.00023085	0.0001167	0.00023	0.00021
'3005	0.000257	-0.00231	0	0.000257	-8E-05	0.000256	-0.00334	0.00026	0.000266	-0.01534	-0.04907	-0.00607	0.000264	0.0002597	0.0002419	0.000257	0.000251
'3001	-1.5E-06	-6.2E-09	0	2.03E-07	-0.00019	-2.6E-07	-0.00253	-6.7E-06	5.73E-06	-0.01099	-0.30796	-0.00458	-4.5E-05	1.2984E-06	1.645E-05	9.41E-07	-5E-05
'3004	0.004978	-0.00658	0	0.004907	0.005022	0.005006	-2.08256	0.005231	0.005446	-0.01662	0.004059	-0.99263	0.007692	0.00463487	0.0036106	0.005086	0.005297
'3003	0.000222	-0.00094	0	0.000257	0.000196	0.000255	-0.01506	0.000258	0.000272	-0.02191	-0.02904	-0.02692	0.000312	0.000246	0.000288	0.000257	0.000236
'3002	0.000187	0.000164	0	0.000177	0.000172	0.000168	-1.50731	0.000192	0.000343	-0.09854	-0.03473	-0.14811	0.001133	0.00024171	-0.0005546	0.0002	-0.00023
Morocco cross-country comparison																**Value in 2020**	

Country	Nigeria	Egypt	Morocco	Algeria	Tunisia	Kenya	Switzerland	Brazil	Belgium	Netherlands	France	Italy	China	India	Germany	SA	USA
'3006	2.98E-05	-0.00011	0	2.92E-05	2.71E-05	2.84E-05	-0.03716	3.28E-05	-0.06857	-0.05695	2.33E-05	-0.03396	-8.6E-05	2.904E-05	-7.028E-05	3.1E-05	9.64E-07
'3005	0.000362	-0.00225	0	0.000361	0.000361	0.000361	-0.00226	0.000367	-0.00763	-0.02226	-0.02164	-0.01099	0.000376	0.0003653 4	0.000353	0.000363	0.000355
'3001	4.03E-07	-3.4E-05	0	1.7E-07	6.45E-08	-4.9E-08	-0.00088	-2.7E-06	-0.00062	-0.01458	-0.46885	-0.0075	-6.5E-05	3.2904E-07	7.471E-06	1.23E-06	-1.1E-05
'3004	0.005618	-0.00664	0	0.005613	0.005603	0.005586	-2.73567	0.005861	-1.36975	-1.11946	-0.01008	-1.55118	0.008854	0.0049911 5	0.003956 2	0.005683	0.006163
'3003	-4E-06	-0.00031	0	1.21E-05	1.18E-05	1.15E-05	-0.04413	1.45E-05	-0.01435	-0.02403	-0.02939	-0.01904	4.55E-05	8.4031E-07	1.711E-05	1.27E-05	-3.7E-05
'3002	0.000366	0.000216	0	0.000357	0.000351	0.000345	-2.28858	0.000462	-1.18509	-0.39651	-0.03425	-0.45561	0.002271	0.0004917	-0.0004327	0.000404	-5.9E-05

Table 43: Algeria cross-country

Algeria cross-country comparison																Value in 2001	
Country	Nigeria	Egypt	Morocco	Algeria	Tunisia	Kenya	Switzerland	Brazil	Belgium	Netherlands	France	Italy	China	India	Germany	SA	USA
'3006	-7.6E-08	-1.4E-05	-5.5E-05	0	-0.00076	-1.9E-06	-0.02802	1.55E-06	1.55E-05	-0.0009	-2.5E-05	-0.01721	-1.6E-05	1.06E-06	-0.00012	2.09E-07	-2.2E-05
'3005	1.39E-05	-0.00038	-8.1E-05	0	-0.0001	1.28E-05	-0.00656	1.62E-05	8.38E-06	-0.00184	-0.05482	-0.00504	2.66E-05	1.39E-05	9.02E-06	1.35E-05	-4.4E-07
'3001	-2.3E-08	-3.2E-07	-2.5E-07	0	-0.00012	-3.7E-07	-0.0036	-6.2E-06	3.62E-06	-1.4E-05	-0.16523	-0.00352	-4.1E-05	-8.3E-07	5.44E-06	1.27E-07	-1.5E-05
'3004	5.22E-05	-0.00641	-0.0022	0	2.35E-05	1.08E-05	-13.8671	0.000151	0.000474	-0.00563	-0.0194	-0.93668	0.000674	-7.7E-06	-0.00072	6.6E-05	0.000444
'3003	-1.6E-07	-0.0011	-3.4E-06	0	-0.00015	-1.8E-06	-0.01546	3.46E-06	1.69E-05	-0.00057	-0.03118	-0.01826	1.87E-05	-2.9E-05	9.51E-06	-1.2E-06	3.07E-06
'3002	6.64E-06	-4.4E-05	-0.00014	0	3E-06	1.38E-06	-0.33636	-7.7E-06	6.15E-05	-0.00152	-0.01893	-0.05438	6.58E-05	5.29E-06	-0.0001	7.58E-06	-0.00015

Algeria cross-country comparison																Value in 2005	
Country	Nigeria	Egypt	Morocco	Algeria	Tunisia	Kenya	Switzerland	Brazil	Belgium	Netherlands	France	Italy	China	India	Germany	SA	USA
'3006	-3.2E-06	-5.7E-06	-0.00011	0	-0.00086	-3E-06	-0.03375	2.09E-06	2.05E-05	-0.00088	-1.2E-05	-0.01182	7.49E-06	2.03E-06	-0.00014	-2.9E-07	-1.1E-05
'3005	4.08E-07	-0.00016	-0.00018	0	-7.9E-05	4.43E-07	-0.00899	4.52E-06	1.26E-05	-0.003	-0.03089	-0.0049	2.07E-05	2.12E-06	-1.2E-06	1.23E-06	-8.2E-06
'3001	-8.9E-07	-6.8E-07	-5.5E-06	0	-0.00035	-8.4E-07	-0.00132	-3.5E-06	5.6E-06	-9.1E-06	-0.17907	-0.00324	-3.7E-05	-2.6E-07	1.29E-05	4.16E-09	-4E-05
'3004	-2.3E-05	-0.00569	-0.0023	0	-2.9E-06	-1.8E-05	-1.55383	0.000198	0.000588	-0.00542	-0.01652	-1.02208	0.001402	-2.9E-05	-0.00095	5.94E-05	0.000374

'3003	1.92E-05	-0.00021	5.72E-06	0	1.29E-05	1.91E-05	-0.03844	1.94E-05	3.75E-05	-0.00039	-0.03981	-0.02264	5.62E-05	4.69E-06	3E-05	1.88E-05	-5.1E-05
'3002	-7.8E-06	-0.00023	-8.7E-05	0	-5E-06	-7E-06	-0.53328	-5.8E-06	8.25E-05	-0.00116	-0.02562	-0.06495	0.000174	1.21E-05	-0.0002	3.6E-06	-0.00028

Algeria cross-country comparison															**Value in 2010**	
Country	**Nigeria**	**Egypt**	**Morocco**	**Algeria**	**Tunisia**	**Kenya**	**Switzerland**	**Brazil**	**Belgium**	**Netherlands**	**France**	**Italy**	**China**	**India**	**Germany**	**SA**	**USA**
'3006	-2.4E-05	-6.9E-06	-0.00013	0	-0.00147	-1.8E-06	-0.04732	6.38E-06	2.3E-05	-0.00094	-1E-05	-0.02035	1.84E-05	7.05E-06	-0.00015	1.26E-07	-1.3E-05
'3005	8.09E-07	-0.00019	-0.00017	0	-7.7E-05	-1.5E-06	-0.00407	3.14E-06	8.57E-06	-0.00147	-0.02434	-0.0059	1.42E-05	1.24E-06	-1.7E-05	-2.7E-07	-3.3E-06
'3001	-5.5E-05	-6.9E-07	-8.8E-07	0	-0.00021	-1.2E-06	-0.00041	-8.6E-06	7.83E-06	-4E-05	-0.31089	-0.00654	-2.9E-05	2.86E-06	6.97E-06	5.22E-07	-5.4E-05
'3004	0.000107	-0.0152	-0.00367	0	3.02E-05	1.29E-05	-1.82924	0.000278	0.000535	-0.01721	-0.00982	-0.92873	0.002134	-3.3E-05	-0.0011	0.000104	0.00021
'3003	-0.00022	-0.00091	-1.1E-05	0	-1.9E-06	-2.9E-06	-0.01361	1.43E-06	1.68E-05	-0.00287	-0.03965	-0.02214	5.08E-05	-3.3E-05	2.62E-05	-2.4E-07	-5.1E-05
'3002	7.73E-06	-2.6E-05	-0.00015	0	-3.5E-05	-1.9E-05	-1.0981	-9.1E-06	0.000123	-0.0022	-0.03616	-0.09927	0.000436	4.41E-05	-0.00063	6.63E-06	-0.00043

Algeria cross-country comparison																Value in 2015	
Country	**Nigeria**	**Egypt**	**Morocco**	**Algeria**	**Tunisia**	**Kenya**	**Switzerland**	**Brazil**	**Belgium**	**Netherlands**	**France**	**Italy**	**China**	**India**	**Germany**	**SA**	**USA**
'3006	8.05E-06	-6.8E-07	-0.00022	0	-0.00232	5.64E-06	-0.0455	1.16E-05	2.69E-05	-0.07096	2.91E-06	-0.02119	-4.3E-05	7.95E-06	-0.00011	7.23E-06	-1.3E-05
'3005	5.11E-08	-0.00256	-0.00026	0	-0.00034	-8E-07	-0.00359	3.57E-06	9.46E-06	-0.0156	-0.04933	-0.00632	7.79E-06	3.07E-06	-1.5E-05	6.79E-07	-5.9E-06
'3001	-1.7E-06	-2.1E-07	-2E-07	0	-0.00019	-4.7E-07	-0.00253	-6.9E-06	5.53E-06	-0.01099	-0.30796	-0.00458	-4.5E-05	1.09E-06	1.62E-05	7.38E-07	-5E-05
'3004	7.13E-05	-0.01149	-0.00491	0	0.000116	9.91E-05	-2.08747	0.000324	0.000539	-0.02153	-0.00085	-0.99754	0.002785	-0.00027	-0.0013	0.000179	0.00039
'3003	-3.4E-05	-0.0012	-0.00026	0	-6.1E-05	-1.4E-06	-0.01532	1.08E-06	1.5E-05	-0.02216	-0.0293	-0.02717	5.6E-05	-1.1E-05	3.14E-05	2.54E-07	-2.1E-05
'3002	1.01E-05	-1.4E-05	-0.00018	0	-5.4E-06	-9.5E-06	-1.50749	1.47E-05	0.000166	-0.09872	-0.03491	-0.14829	0.000956	6.45E-05	-0.00073	2.28E-05	-0.00041

Algeria cross-country comparison																Value in 2020	
Country	**Nigeria**	**Egypt**	**Morocco**	**Algeria**	**Tunisia**	**Kenya**	**Switzerland**	**Brazil**	**Belgium**	**Netherlands**	**France**	**Italy**	**China**	**India**	**Germany**	**SA**	**USA**
'3006	6.18E-07	-0.00014	-2.9E-05	0	-2.1E-06	-8.4E-07	-0.03719	3.57E-06	-0.0686	-0.05698	-5.9E-06	-0.03399	-0.00011	-1.9E-07	-1E-04	1.73E-06	-2.8E-05
'3005	8.38E-07	-0.00262	-0.00036	0	1.84E-07	4.85E-08	-0.00262	5.56E-06	-0.008	-0.02262	-0.022	-0.01135	1.46E-05	4.27E-06	-8.1E-06	1.7E-06	-6.2E-06
'3001	2.33E-07	-3.4E-05	-1.7E-07	0	-1.1E-07	-2.2E-07	-0.00088	-2.9E-06	-0.00062	-0.01458	-0.46885	-0.0075	-6.5E-05	1.59E-07	7.3E-06	1.06E-06	-1.2E-05

'3004	5.1E-06	-0.01226	-0.00561	0	-9.9E-06	-2.7E-05	-2.74128	0.000248	-1.37536	-1.12507	-0.0157	-1.55679	0.003241	-0.00062	-0.00166	7.05E-05	0.000551
'3003	-1.6E-05	-0.00032	-1.2E-05	0	-2.8E-07	-6E-07	-0.04414	2.4E-06	-0.01437	-0.02404	-0.02941	-0.01905	3.34E-05	-1.1E-05	5.04E-06	5.98E-07	-4.9E-05
'3002	9.28E-06	-0.00014	-0.00036	0	-6.2E-06	-1.2E-05	-2.28894	0.000104	-1.18545	-0.39687	-0.03461	-0.45596	0.001914	0.000135	-0.00079	4.7E-05	-0.00042

Table 44: Tunisia cross-country

Tunisia cross-country comparison																**Value in 2001**	
Country	**Nigeria**	**Egypt**	**Morocco**	**Algeria**	**Tunisia**	**Kenya**	**Switzerland**	**Brazil**	**Belgium**	**Netherlands**	**France**	**Italy**	**China**	**India**	**Germany**	**SA**	**USA**
'3006	0.000763	0.000749	0.000708	0.000763	0	0.000761	-0.02726	0.000764	0.000778	-0.00013	0.000738	-0.01645	0.000746	0.00076375	0.0006399	0.000763	0.000741
'3005	0.000116	-0.00028	2.16E-05	0.000102	0	0.000115	-0.00646	0.000118	0.000111	-0.00173	-0.05471	-0.00493	0.000129	0.00011624	0.0001113	0.000116	0.000102
'3001	0.000124	0.000123	0.000123	0.000124	0	0.000123	-0.00347	0.000117	0.000127	0.000109	-0.16511	-0.0034	8.26E-05	0.0001227	0.0001289	0.000124	0.000108
'3004	2.87E-05	-0.00644	-0.00222	-2.4E-05	0	-1.3E-05	-13.8671	0.000127	0.00045	-0.00565	-0.01942	-0.9367	0.00065	-3.119E-05	-0.0007394	4.25E-05	0.00042
'3003	0.00015	-0.00095	0.000147	0.00015	0	0.000149	-0.01531	0.000154	0.000167	-0.00042	-0.03103	-0.0181	0.000169	0.000121	0.0001598	0.000149	0.000153
'3002	3.64E-06	-4.7E-05	-0.00014	-3E-06	0	-1.6E-06	-0.33637	-1.1E-05	5.85E-05	-0.00152	-0.01894	-0.05438	6.28E-05	2.2847E-06	-0.0001078	4.58E-06	-0.00015
Tunisia cross-country comparison																**Value in 2005**	

Country	Nigeria	Egypt	Morocco	Algeria	Tunisia	Kenya	Switzerland	Brazil	Belgium	Netherlands	France	Italy	China	India	Germany	SA	USA
'3006	0.000855	0.000853	0.000751	0.000859	0	0.000856	-0.03289	0.000861	0.000879	-2.6E-05	0.000846	-0.01096	0.000866	0.0008607	0.0007219	0.000858	0.000847
'3005	7.98E-05	-7.7E-05	-0.0001	7.94E-05	0	7.99E-05	-0.00891	8.4E-05	9.21E-05	-0.00292	-0.03081	-0.00482	0.0001	8.1555E-05	7.8245E-05	8.07E-05	7.12E-05
'3001	0.000346	0.000346	0.000341	0.000347	0	0.000346	-0.00097	0.000343	0.000352	0.000338	-0.17872	-0.0029	0.00031	0.0003466 1	0.0003597 7	0.000347	0.000307
'3004	-2E-05	-0.00568	-0.00229	2.85E-06	0	-1.5E-05	-1.55383	0.000201	0.00059	-0.00542	-0.01652	-1.02208	0.001405	-2.621E-05	-0.0009519	6.23E-05	0.000377
'3003	6.38E-06	-0.00022	-7.1E-06	-1.3E-05	0	6.26E-06	-0.03845	6.57E-06	2.47E-05	-0.00041	-0.03982	-0.02265	4.34E-05	-8.164E-06	1.7152E-05	5.96E-06	-6.4E-05
'3002	-2.8E-06	-0.00022	-8.2E-05	4.98E-06	0	-2E-06	-0.53327	-8.1E-07	8.75E-05	-0.00115	-0.02562	-0.06495	0.000179	1.707E-05	-0.0001986	8.58E-06	-0.00028
Tunisia cross-country comparison																**Value in 2010**	
Country	**Nigeria**	**Egypt**	**Morocco**	**Algeria**	**Tunisia**	**Kenya**	**Switzerland**	**Brazil**	**Belgium**	**Netherlands**	**France**	**Italy**	**China**	**India**	**Germany**	**SA**	**USA**
'3006	0.001442	0.001458	0.001338	0.001465	0	0.001463	-0.04586	0.001472	0.001488	0.000527	0.001455	-0.01888	0.001484	0.0014723 8	0.0013141 9	0.001465	0.001452
'3005	7.81E-05	-0.00012	-9.1E-05	7.73E-05	0	7.57E-05	-0.00399	8.04E-05	8.58E-05	-0.00139	-0.02426	-0.00582	9.15E-05	7.8505E-05	6.0598E-05	7.7E-05	7.4E-05
'3001	0.000155	0.00021	0.000209	0.00021	0	0.000209	-0.0002	0.000202	0.000218	0.00017	-0.31067	-0.00633	0.000181	0.0002131 6	0.0002172 7	0.00021 1	0.000156

'3004	7.63E-05	-0.01523	-0.0037	-3E-05	0	-1.7E-05	-1.82927	0.000248	0.000505	-0.01724	-0.00985	-0.92876	0.002104	-6.365E-05	-0.0011316	7.33E-05	0.00018
'3003	-0.00022	-0.00091	-9E-06	1.92E-06	0	-9.5E-07	-0.01361	3.35E-06	1.87E-05	-0.00287	-0.03965	-0.02214	5.27E-05	-3.106E-05	2.8111E-05	1.68E-06	-4.9E-05
'3002	4.28E-05	9.35E-06	-0.00012	3.5E-05	0	1.64E-05	-1.09806	2.59E-05	0.000158	-0.00217	-0.03613	-0.09924	0.000471	7.9102E-05	-0.0005971	4.17E-05	-0.00039

Tunisia cross-country comparison																**Value in 2015**	
Country	**Nigeria**	**Egypt**	**Morocco**	**Algeria**	**Tunisia**	**Kenya**	**Switzerland**	**Brazil**	**Belgium**	**Netherlands**	**France**	**Italy**	**China**	**India**	**Germany**	**SA**	**USA**
'3006	0.002324	0.002315	0.002093	0.002316	0	0.002322	-0.04319	0.002328	0.002343	-0.06864	0.002319	-0.01887	0.002273	0.00232393	0.00220976	0.002323	0.002303
'3005	0.000337	-0.00223	8E-05	0.000337	0	0.000336	-0.00326	0.00034	0.000346	-0.01526	-0.04899	-0.00599	0.000344	0.00033974	0.00032198	0.000337	0.000331
'3001	0.000188	0.000189	0.000189	0.000189	0	0.000189	-0.00234	0.000182	0.000195	-0.0108	-0.30777	-0.00439	0.000144	0.00019044	0.00020559	0.00019	0.000139
'3004	-4.4E-05	-0.0116	-0.00502	-0.00012	0	-1.7E-05	-2.08758	0.000208	0.000423	-0.02164	-0.00096	-0.99765	0.002669	-0.0003876	-0.0014119	6.31E-05	0.000275
'3003	2.65E-05	-0.00114	-0.0002	6.1E-05	0	5.96E-05	-0.01526	6.21E-05	7.6E-05	-0.0221	-0.02924	-0.02711	0.000117	5.049E-05	9.2445E-05	6.13E-05	4.01E-05

'3002	1.54E-05	-8.3E-06	-0.00017	5.37E-06	0	-4.1E-06	-1.50748	2.01E-05	0.000171	-0.09871	-0.0349	-0.14828	0.000962	6.986E-05	-0.0007264	2.82E-05	-0.00041
Tunisia cross-country comparison																**Value in 2020**	
Country	**Nigeria**	**Egypt**	**Morocco**	**Algeria**	**Tunisia**	**Kenya**	**Switzerland**	**Brazil**	**Belgium**	**Netherlands**	**France**	**Italy**	**China**	**India**	**Germany**	**SA**	**USA**
'3006	2.71E-06	-0.00013	-2.7E-05	2.09E-06	0	1.26E-06	-0.03719	5.66E-06	-0.0686	-0.05698	-3.8E-06	-0.03399	-0.00011	1.9077E-06	-9.741E-05	3.82E-06	-2.6E-05
'3005	6.54E-07	-0.00262	-0.00036	-1.8E-07	0	-1.4E-07	-0.00262	5.38E-06	-0.008	-0.02262	-0.022	-0.01135	1.44E-05	4.086E-06	-8.269E-06	1.52E-06	-6.3E-06
'3001	3.38E-07	-3.4E-05	-6.4E-08	1.05E-07	0	-1.1E-07	-0.00088	-2.8E-06	-0.00062	-0.01458	-0.46885	-0.0075	-6.5E-05	2.6456E-07	7.4067E-06	1.17E-06	-1.1E-05
'3004	1.5E-05	-0.01225	-0.0056	9.93E-06	0	-1.7E-05	-2.74127	0.000258	-1.37535	-1.12506	-0.01569	-1.55678	0.003251	-0.0006117	-0.0016466	8.04E-05	0.00056
'3003	-1.6E-05	-0.00032	-1.2E-05	2.8E-07	0	-3.2E-07	-0.04414	2.68E-06	-0.01436	-0.02404	-0.02941	-0.01905	3.37E-05	-1.095E-05	5.3189E-06	8.78E-07	-4.9E-05
'3002	1.55E-05	-0.00013	-0.00035	6.23E-06	0	-6.3E-06	-2.28893	0.000111	-1.18544	-0.39686	-0.0346	-0.45596	0.00192	0.00014074	-0.0007836	5.32E-05	-0.00041

Table 45. Kenya cross-country

Kenya cross-country comparison															Value in 2001	
Country	**Nigeria**	**Egypt**	**Morocco**	**Algeria**	**Tunisia**	**Kenya**	**Switzerland**	**Brazil**	**Belgium**	**Netherlands**	**France**	**Italy**	**China**	**India**	**Germany**	**SA**	**USA**
'3006	1.81E-06	-1.2E-05	-5.3E-05	1.89E-06	-0.00076	0	-0.02802	3.44E-06	1.74E-05	-0.0009	-2.3E-05	-0.01721	-1.4E-05	2.94E-06	-0.00012	2.1E-06	-2E-05
'3005	1.11E-06	-0.0004	-9.4E-05	-1.3E-05	-0.00012	0	-0.00657	3.37E-06	-4.4E-06	-0.00185	-0.05483	-0.00505	1.38E-05	1.12E-06	-3.8E-06	7.28E-07	-1.3E-05
'3001	3.5E-07	5.55E-08	1.19E-07	3.73E-07	-0.00012	0	-0.00359	-5.8E-06	4E-06	-1.4E-05	-0.16523	-0.00352	-4.1E-05	-4.6E-07	5.82E-06	5E-07	-1.5E-05
'3004	4.14E-05	-0.00643	-0.00221	-1.1E-05	1.28E-05	0	-13.8671	0.00014	0.000463	-0.00564	-0.01941	-0.93669	0.000663	-1.8E-05	-0.00073	5.52E-05	0.000433
'3003	1.63E-06	-0.0011	-1.7E-06	1.79E-06	-0.00015	0	-0.01545	5.25E-06	1.87E-05	-0.00057	-0.03118	-0.01825	2.05E-05	-2.8E-05	1.13E-05	6.18E-07	4.86E-06
'3002	5.26E-06	-4.5E-05	-0.00014	-1.4E-06	1.62E-06	0	-0.33637	-9.1E-06	6.01E-05	-0.00152	-0.01894	-0.05438	6.45E-05	3.9E-06	-0.00011	6.2E-06	-0.00015
Kenya cross-country comparison															**Value in 2005**	
Country	**Nigeria**	**Egypt**	**Morocco**	**Algeria**	**Tunisia**	**Kenya**	**Switzerland**	**Brazil**	**Belgium**	**Netherlands**	**France**	**Italy**	**China**	**India**	**Germany**	**SA**	**USA**
'3006	-2E-07	-2.8E-06	-0.0001	2.98E-06	-0.00086	0	-0.03375	5.07E-06	2.35E-05	-0.00088	-9.3E-06	-0.01181	1.05E-05	5.02E-06	-0.00013	2.69E-06	-8.2E-06
'3005	-3.5E-08	-0.00016	-0.00018	-4.4E-07	-8E-05	0	-0.00899	4.08E-06	1.22E-05	-0.003	-0.03089	-0.0049	2.02E-05	1.68E-06	-1.6E-06	7.84E-07	-8.7E-06
'3001	-5.2E-08	1.54E-07	-4.7E-06	8.38E-07	-0.00035	0	-0.00132	-2.7E-06	6.44E-06	-8.2E-06	-0.17907	-0.00324	-3.6E-05	5.74E-07	1.37E-05	8.42E-07	-3.9E-05

'3004	-4.2E-06	-0.00567	-0.00228	1.83E-05	1.54E-05	0	-1.55381	0.000216	0.000606	-0.0054	-0.01651	-1.02207	0.001421	-1.1E-05	-0.00094	7.77E-05	0.000393
'3003	1.19E-07	-0.00023	-1.3E-05	-1.9E-05	-6.3E-06	0	-0.03846	3.1E-07	1.84E-05	-0.00041	-0.03983	-0.02266	3.71E-05	-1.4E-05	1.09E-05	-3.1E-07	-7.1E-05
'3002	-8.5E-07	-0.00022	-8E-05	6.95E-06	1.98E-06	0	-0.53327	1.17E-06	8.94E-05	-0.00115	-0.02562	-0.06495	0.000181	1.9E-05	-0.0002	1.06E-05	-0.00028

Kenya cross-country comparison																**Value in 2010**	
Country	**Nigeria**	**Egypt**	**Morocco**	**Algeria**	**Tunisia**	**Kenya**	**Switzerland**	**Brazil**	**Belgium**	**Netherlands**	**France**	**Italy**	**China**	**India**	**Germany**	**SA**	**USA**
'3006	-2.2E-05	-5.1E-06	-0.00013	1.84E-06	-0.00146	0	-0.04732	8.22E-06	2.48E-05	-0.00094	-8.4E-06	-0.02035	2.02E-05	8.89E-06	-0.00015	1.97E-06	-1.1E-05
'3005	2.33E-06	-0.00019	-0.00017	1.52E-06	-7.6E-05	0	-0.00406	4.66E-06	1.01E-05	-0.00147	-0.02433	-0.0059	1.58E-05	2.76E-06	-1.5E-05	1.25E-06	-1.8E-06
'3001	-5.4E-05	4.74E-07	2.82E-07	1.16E-06	-0.00021	0	-0.00041	-7.5E-06	8.99E-06	-3.9E-05	-0.31088	-0.00654	-2.8E-05	4.02E-06	8.13E-06	1.68E-06	-5.3E-05
'3004	9.36E-05	-0.01522	-0.00369	-1.3E-05	1.73E-05	0	-1.82925	0.000265	0.000522	-0.01722	-0.00983	-0.92874	0.002122	-4.6E-05	-0.00111	9.06E-05	0.000197
'3003	-0.00022	-0.00091	-8E-06	2.87E-06	9.46E-07	0	-0.01361	4.3E-06	1.96E-05	-0.00286	-0.03965	-0.02214	5.36E-05	-3E-05	2.91E-05	2.63E-06	-4.8E-05
'3002	2.64E-05	-7.1E-06	-0.00013	1.86E-05	-1.6E-05	0	-1.09808	9.54E-06	0.000142	-0.00218	-0.03614	-0.09925	0.000455	6.27E-05	-0.00061	2.53E-05	-0.00041

Kenya cross-country comparison																**Value in 2015**	
Country	**Nigeria**	**Egypt**	**Morocco**	**Algeria**	**Tunisia**	**Kenya**	**Switzerland**	**Brazil**	**Belgium**	**Netherlands**	**France**	**Italy**	**China**	**India**	**Germany**	**SA**	**USA**
'3006	2.41E-06	-6.3E-06	-0.00023	-5.6E-06	-0.00232	0	-0.04551	5.97E-06	2.13E-05	-0.07097	-2.7E-06	-0.02119	-4.9E-05	2.32E-06	-0.00011	1.59E-06	-1.9E-05

'3005	8.55E-07	-0.00256	-0.00026	8.04E-07	-0.00034	0	-0.00359	4.38E-06	1.03E-05	-0.0156	-0.04933	-0.00632	8.59E-06	3.88E-06	-1.4E-05	1.48E-06	-5.1E-06
'3001	-1.2E-06	2.57E-07	2.63E-07	4.66E-07	-0.00019	0	-0.00253	-6.5E-06	6E-06	-0.01099	-0.30796	-0.00458	-4.5E-05	1.56E-06	1.67E-05	1.2E-06	-5E-05
'3004	-2.8E-05	-0.01159	-0.00501	-9.9E-05	1.67E-05	0	-2.08756	0.000225	0.00044	-0.02163	-0.00095	-0.99764	0.002686	-0.00037	-0.0014	7.98E-05	0.000291
'3003	-3.3E-05	-0.0012	-0.00026	1.43E-06	-6E-05	0	-0.01532	2.51E-06	1.64E-05	-0.02216	-0.0293	-0.02717	5.74E-05	-9.1E-06	3.29E-05	1.68E-06	-2E-05
'3002	1.96E-05	-4.2E-06	-0.00017	9.48E-06	4.1E-06	0	-1.50748	2.42E-05	0.000175	-0.09871	-0.0349	-0.14828	0.000966	7.4E-05	-0.00072	3.23E-05	-0.0004

Kenya cross-country comparison															**Value in 2020**	
Country	**Nigeria**	**Egypt**	**Morocco**	**Algeria**	**Tunisia**	**Kenya**	**Switzerland**	**Brazil**	**Belgium**	**Netherlands**	**France**	**Italy**	**China**	**India**	**Germany**	**SA**	**USA**
'3006	1.46E-06	-0.00014	-2.8E-05	8.39E-07	-1.3E-06	0	-0.03719	4.41E-06	-0.0686	-0.05698	-5.1E-06	-0.03399	-0.00011	6.52E-07	-9.9E-05	2.57E-06	-2.7E-05
'3005	7.89E-07	-0.00262	-0.00036	-4.8E-08	1.36E-07	0	-0.00262	5.51E-06	-0.008	-0.02262	-0.022	-0.01135	1.46E-05	4.22E-06	-8.1E-06	1.65E-06	-6.2E-06
'3001	4.52E-07	-3.3E-05	4.91E-08	2.19E-07	1.14E-07	0	-0.00088	-2.7E-06	-0.00062	-0.01458	-0.46885	-0.0075	-6.5E-05	3.78E-07	7.52E-06	1.28E-06	-1.1E-05
'3004	3.19E-05	-0.01223	-0.00559	2.69E-05	1.69E-05	0	-2.74126	0.000275	-1.37533	-1.12504	-0.01567	-1.55677	0.003268	-0.00059	-0.00163	9.73E-05	0.000577
'3003	-1.5E-05	-0.00032	-1.1E-05	5.99E-07	3.19E-07	0	-0.04414	3E-06	-0.01436	-0.02404	-0.02941	-0.01905	3.4E-05	-1.1E-05	5.64E-06	1.2E-06	-4.8E-05
'3002	2.18E-05	-0.00013	-0.00034	1.25E-05	6.27E-06	0	-2.28893	0.000117	-1.18544	-0.39685	-0.0346	-0.45595	0.001927	0.000147	-0.00078	5.95E-05	-0.0004

Appendix L: Temporal Comparison of African countries

Table 46: South Africa Temporal comparison results

SA over time comparison											
Product code	**2002**	**2004**	**2006**	**2008**	**2010**	**2012**	**2014**	**2016**	**2018**	**2020**	**2022**
'3006	3.87E-07	-2.4E-07	2.16E-07	-3.5E-07	1.62E-06	-3.9E-07	2.03E-07	-7.7E-07	-4E-07	4.23E-07	3.01E-07
'3005	1.52E-07	1.14E-07	2.95E-07	-9.6E-08	7.39E-08	2.66E-07	2.05E-07	-1.1E-07	-3.4E-08	-1.1E-07	2.56E-07
'3001	5.63E-08	-7.8E-08	1.27E-07	-5.3E-08	-4.1E-07	2.69E-07	1.45E-07	1.2E-07	1.12E-11	-2.6E-07	1.98E-07
'3004	-3.2E-06	-4.6E-06	2.5E-06	5.96E-06	1.62E-06	1.36E-05	-2.7E-06	1.39E-06	2.56E-06	-2.1E-05	7.25E-06
'3003	1.82E-06	-7.2E-07	-7.7E-07	-7.2E-07	-6E-07	6.43E-07	8.59E-07	-1.3E-07	-1E-07	-3.9E-07	-3.6E-07
'3002	6.08E-07	-7.8E-07	-7.2E-07	-9.8E-07	-2E-06	-3.8E-07	-3E-06	-2E-06	-1.1E-06	-1.4E-05	1.69E-05

Table 47:Nigeria Temporal Comparison results

Nigeria over time comparison											
Product code	**2002**	**2004**	**2006**	**2008**	**2010**	**2012**	**2014**	**2016**	**2018**	**2020**	**2022**
'3006	-1.6E-07	2.41E-06	-2.9E-06	-0.00074	2.56E-05	-1.1E-06	-4.6E-07	6.8E-07	7.52E-06	-0.00025	-8.3E-08
'3005	-5.7E-08	1.38E-06	-1.8E-06	1.88E-07	-6.1E-07	-1.5E-06	2.54E-06	-6.2E-08	-1.4E-07	3.52E-07	2.66E-07
'3001	-3.8E-09	4.74E-07	5.15E-06	-2E-05	-2.6E-05	1.72E-05	-1E-05	-1.7E-06	3.16E-06	-2.3E-06	-2.3E-09
'3004	-9.7E-06	6.12E-05	-9.5E-05	-5.6E-05	-3E-05	-0.00017	-0.00122	-1.8E-05	-1E-05	5.7E-06	-2.3E-06
'3003	-4.5E-08	2.2E-06	-2.9E-06	6.92E-05	-4.2E-05	-6.7E-05	-8.3E-05	-2.8E-05	-3.4E-06	1.39E-05	-1.9E-07
'3002	-8.6E-07	8.64E-06	-1.5E-05	-5.4E-06	-3.9E-06	-8.9E-06	-6.6E-06	3.99E-06	-4.8E-06	4.77E-06	2.38E-06

Table 48: Egypt Temporal Comparison results

Egypt over time comparison											
Product code	**2002**	**2004**	**2006**	**2008**	**2010**	**2012**	**2014**	**2016**	**2018**	**2020**	**2022**
'3006	-4.1E-06	1.36E-05	2.73E-06	4.59E-06	-0.00012	-4.3E-06	-3.7E-06	7.12E-06	9.02E-06	9.96E-05	-8.3E-08
'3005	-2.1E-05	2.88E-05	-4.4E-05	-2.3E-06	-0.00174	0.001157	0.00051	0.000387	-9.5E-05	0.000198	2.66E-07
'3001	5.94E-07	-8.1E-05	2.36E-09	-9.9E-08	-1.9E-06	-1.7E-06	3.02E-06	2E-05	8.26E-06	-3.4E-06	-2.3E-09
'3004	0.001911	-0.00127	-0.00108	0.00374	-0.0018	0.001159	-0.00049	0.002269	-0.00255	0.00103	-2.3E-06
'3003	7.96E-05	-0.00051	0.000251	0.000121	0.000405	0.000482	0.000877	0.000335	-0.00051	-0.00043	-1.9E-07
'3002	0.00025	-2.5E-05	-0.0001	2.49E-05	-2.7E-05	-3.4E-07	-2.8E-06	-5E-07	1.44E-05	0.000105	2.38E-06

Table 49: Morocco Temporal Comparison results

Morocco over time comparison											
Product code	**2002**	**2004**	**2006**	**2008**	**2010**	**2012**	**2014**	**2016**	**2018**	**2020**	**2022**
'3006	5.95E-05	3.07E-05	2.62E-06	-2.8E-06	-5.9E-05	1.08E-05	5.52E-05	-2E-05	7.52E-05	2.31E-06	-5.5E-08
'3005	-4E-05	-6.6E-05	-6.6E-05	3.76E-05	-0.00023	5.56E-05	1.91E-05	3.91E-05	4.35E-05	4.52E-05	2.67E-08
'3001	-1.2E-08	1.34E-10	-3.9E-06	-6.3E-06	-3.3E-08	3.56E-08	1.31E-09	6.34E-10	9.13E-09	-4E-05	-4.6E-10
'3004	0.000198	0.00026	-0.0001	0.000433	-0.00014	0.00129	-7.1E-05	0.000612	-0.00011	0.000341	-7.6E-07
'3003	-1.9E-07	6.38E-06	8.23E-05	-2.2E-05	3.59E-06	1.28E-05	7.26E-05	-0.00018	2.49E-05	-0.00011	-2.7E-07
'3002	-2.6E-05	3.06E-05	5.03E-05	5.45E-05	4.28E-05	4.57E-06	-0.00022	-2.6E-05	8.6E-05	-0.00011	2.68E-06

Table 50: Algeria Temporal Comparison results

Algeria over time comparison											
Product code	**2002**	**2004**	**2006**	**2008**	**2010**	**2012**	**2014**	**2016**	**2018**	**2020**	**2022**
'3006	-1.1E-07	-2.2E-07	1.51E-07	-6.7E-07	4.03E-07	-2.5E-07	1.69E-06	4.9E-05	-7.2E-06	5.89E-07	-7.7E-07
'3005	-1.2E-05	1.73E-06	4.45E-07	3.15E-06	3.18E-08	9.41E-07	-6.5E-07	2.4E-08	2.13E-07	4.35E-07	-3.7E-07
'3001	1.48E-08	-7.3E-08	0.00031	-1.6E-07	-1.1E-07	1.34E-07	1.5E-07	9.23E-08	-2.3E-08	1.21E-07	-2.3E-07
'3004	1.17E-05	-1.9E-06	1.41E-05	-0.00011	-0.0001	4.39E-05	2.87E-05	0.000211	-0.00022	1.03E-05	-1.6E-05
'3003	9.04E-08	8.51E-06	-2.2E-05	2.32E-06	-1.2E-05	7.4E-06	-5.1E-06	2.38E-05	-3.5E-07	2.85E-07	-6.9E-07
'3002	4.28E-06	-1.7E-06	-9.5E-07	-7.2E-06	1.55E-06	-1.7E-06	-5.8E-05	1.62E-05	-7.8E-05	4.26E-06	-9.7E-06

Table 51: Tunisia Temporal Comparison results

Tunisia over time comparison											
Product code	**2002**	**2004**	**2006**	**2008**	**2010**	**2012**	**2014**	**2016**	**2018**	**2020**	**2022**
'3006	-0.00012	0.000724	0.000121	0.000163	-0.00065	0.000564	-0.00033	6.14E-05	0.000689	-0.00348	-1.7E-08
'3005	7.84E-05	3.63E-05	-6.8E-05	9.33E-06	-0.00012	4.91E-05	0.000138	-1.3E-05	5.84E-05	-0.00038	-4.9E-08
'3001	2.73E-05	-5.1E-05	-0.00018	-8.7E-05	4.93E-05	2.57E-05	-8.4E-05	4.32E-05	-6.4E-06	-0.00016	-7.8E-09
'3004	1.32E-05	8.02E-06	7.96E-07	-7.7E-07	7.95E-06	1.06E-06	-1.3E-05	8.59E-06	1.53E-05	-4.3E-06	-2.9E-06
'3003	-0.00013	-3E-05	8.65E-07	-4.5E-05	-5.8E-06	-5.3E-06	1.86E-06	-3E-05	1.4E-06	-1.2E-05	-1.3E-07
'3002	2.76E-05	-1.4E-07	-9.9E-08	-6.3E-07	2.19E-05	-2.7E-07	-5.6E-07	-6.2E-07	-3E-07	-2E-06	6.59E-07

Table 52: Kenya Temporal Comparison results

Kenya over time comparison											
Product code	**2002**	**2004**	**2006**	**2008**	**2010**	**2012**	**2014**	**2016**	**2018**	**2020**	**2022**
'3006	1.04E-07	7.07E-08	3.57E-08	-3.8E-08	-7.9E-09	1.53E-09	-4.2E-08	-9.6E-08	-3.6E-08	-5.3E-08	1.13E-08
'3005	1.25E-07	1.52E-07	1.21E-08	-3.3E-08	4.26E-08	4.33E-08	-2.6E-08	4.34E-09	1.05E-08	-2.8E-08	-8.4E-10
'3001	1.56E-08	1.19E-08	1.9E-09	-1.4E-08	-3.1E-09	1.93E-08	-1.5E-09	6.51E-09	6.98E-10	-2.8E-08	4.33E-09
'3004	2.39E-06	2.88E-06	1.3E-06	1.02E-06	4.91E-07	5.51E-07	-1.7E-06	-4.4E-07	-1.3E-06	-2.2E-06	-3.9E-08
'3003	3.42E-07	8.62E-08	-7.3E-08	-2.4E-08	-2.5E-07	-1.4E-07	-3.3E-08	-1.4E-07	4.28E-08	-7.5E-08	-4E-08
'3002	1.55E-07	2.14E-08	5.55E-08	3.12E-08	3.43E-08	-3.1E-07	-8.9E-08	-1.8E-07	1.17E-07	-1.2E-06	8.99E-07

Appendix M: Examples of patented pharmaceutical products and price comparison

Table 62. Patents granted on Transtuzumab in South Africa

PATENT TITLE	PATENT HOLDER	CIPC NUMBER	LODGING DATE	GRANT DATE	EXPIRY DATE	LEGAL STATUS	PCT NUMBER
Protein purification by ion exchange chromatography	Genentech Inc.*	2000/05879	20-October-2000	22-Oct-2001	20-Octo-2020	Granted	PCT/US99/09637
Dosages for treatment with anti-erbb2 antibodies	Genentech Inc.	2002/01229	13-Feb-2002	25-Jun-2023	13-Feb-2022	Granted	PCT/US00/23391
Her-2 antibody composition	Genentech Inc.	2007/01234	2-Feb-2007	31-Dec-2008	2-Feb 2027	Granted	PCT/US05/025084
Combinations of an anti-her-2 antibody-drug conjugate and chemotherapeutic agents, and methods of use	Genentech Inc.	2010/06186	30-Aug-2010	30-Nov-2011	30-Aug-2030	Granted	PCT/US09/036608
Treatment of her-2-positive cancer with paclitaxel and trastuzumab-mcc-dm1	Genentech Inc.	2013/03611	17-May-2013	30-Jul-2014	17-May-2033	Granted	

Table 63. Prices of Trastuzumab in South Africa and India

DOSAGE AND FORMULATION	PRICES OF ORIGINATOR PRODUCTS IN SA PRIVATE SECTOR [2]	PRICES OF ORIGINATOR PRODUCTS IN SA PUBLIC SECTOR [1]	PRICES OF ORIGINATOR PRODUCT IN INDIA [11]	PRICES OF CLONE PRODUCT IN INDIA [11]	PRICES (IN ZAR) OF BIOSIMILAR PRODUCT IN INDIA [11]
440 mg vial ++	ZAR 55.20 US$ 3.90	Unknown	ZAR60.71 US$ 4.29	ZAR 30.70 US$ 2.17 (Roche/Emcure)	ZAR 17.22 US$1.22 (Biocon/Mylan)
440 mg vial +	ZAR 24,290.00 US$1,717.82	Unknown	ZAR 26.723.00 US$ 1.889.89	ZAR 13.524.00 US$ 956.44 (Roche/Emcure)	ZAR 7.576 US$535.79 (Biocon/Mylan)
150 mg vial ++					ZAR 18.75

		US$1.32 (Biocon/Mylan)
150 mg vial +		ZAR 2,813.00 US$198.94 (Biocon/Mylan)

+price per single vial ++price per single mg

Table 64. Prices of Bortezomb in South Africa and India

Generic versions of bortezomib are available in India at prices 75% lower than those charged for the originator Product in South Africa.

PATENT TITLE	PATENT HOLDER	CIPC NUMBER	LODGING DATE	GRANT DATE	EXPIRY DATE	LEGAL STATUS	PCT NUMBER
Boronic ester and acid compounds,synthesis and uses	Millennium Pharmaceuticals	1995/09119	27-Octo-1995	31-Jul-1996	27-Oct-2015	Granted	PCT/US1995/014117
Boronate ester compounds and pharmaceutical compositions thereof	Millennium Pharmaceuticals	2010/09177	21-Dec-2010	28-Mar-2012	21-Dec-2030	Granted	PCT/US09/003602
Boronate ester compounds and pharmaceutical compositions thereof	Millennium Pharmaceuticals	2011/09368	20- Dec-2011	30-Octo-2013	20-Dec-2031	Granted	N/A
Boronate ester compounds and pharmaceutical compositions thereof	Millennium Pharmaceuticals	2015/04133	08-Jun-2015	N/A	8-Jun-2035	Granted	N/A

Table 65. Prices of Trastuzumab in South Africa and India

Dosage and formulation	Prices of originator products in SA private sector [2]	Prices of originator products in SA public sector [1]	Prices of generic products in India [1]	Prices of originator product in India [11]

3.5 mg/ml vial++	ZAR 4,178.70 US$ 295.52	N/A	ZAR 1.079.22 US$76.32 (Natco, Glenmark)	ZAR 3,692.87 US$ 261.16
3.5 mg/ml vial+	ZAR 14,625.46 US$ 1,034.33		ZAR 3.777.27 US$267.13 (Natco, Glenmark)	ZAR 12,925.00 US$ 914.07
2mg/ml vial++			ZAR 1.338.33 US$94.64 (Natco, Glenmark)	
2mg/ml vial+			ZAR 2.676.66 US$189.30 (Natco, Glenmark)	

RHODES UNIVERSITY
Where leaders learn

Appendix N

RESEARCH ETHICS DECLARATION

To be included in the Appendices of research papers / dissertations / theses submitted for postgraduate examination where research did not involve interaction with human participants, or the use of animal subjects, and therefore did not require research ethics approval.

Candidates whose research did require ethics clearance must include their ethics approval letter in the Appendix of their examination submission.

Name of Candidate: Nwabisa Malimba

Name of Supervisor: **MUTAMBARA, Tsitsi Effie**

Degree: Doctor of Philosophy

Title of research: Absorptive Capacity and growth nexus in the South African Pharmaceutical Sector: An intra-industry trade perspective

DECLARATION

I declare that my research did not require ethical clearance because (tick all that apply):

I did not collect data from human participants or animal subjects	x
I used previously collected data that had already received ethics clearance.	
I analysed documents / open-access digital texts that are freely available in the public domain.	x
I did a literature review/analysis of theoretical or secondary material only.	x
I used human datasets of non-sensitive information that are either anonymous (identifiers were never collected) or have been deidentified (identifiers have been completely removed).	
I used commercially produced human biological material (e.g. established human cell lines).	

I observed people in public spaces and natural environments where they had no reasonable expectation of privacy and I did not interact with them or intervene in any way.	
I used non-living animal materials (eg bones of already deceased organisms or fossils) while complying with any custody and/or jurisdiction requirements.	
I did a content analysis of public media (newspapers, advertisements, and social media posts).	
I did a simulation study with no real-world consequences and does not involve disturbing or distressing content.	
I observed flora, fauna, and ecosystems without interfering with or disturbing their natural state while complying with any jurisdiction requirements.	
Other (Please provide details):	

Signature of Candidate:

Date: 16/04/2025

Signature of Supervisor:

Date: 16/04/2025