Project Outcomes

"Models, Determinants and Policies for Cathing-Up along the GVC"

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CATCHAIN
CATCHING-UP ALONG THE GLOBAL VALUE CHAIN: MODELS, DETERMINANTS AND POLICY IMPLICATIONS

GRANT AGREEMENT
NUMBER — 778398— CatChain

Models, Determinants and Policies for Cathing-Up along the GVC

1. INTRODUCTION

By contrasting existing theoretical models and emerging BMs, the project will successfully deliver sound analysis of the existing policies impact, the identification of their emerging limits and promoting the design of efficient incentives industrial and useful policy recommendations and BMs in order to facilitate the entrance and upgrade of SMEs into GVCs, this will boost competitiveness and growth of Europe as a whole. EU governments, individually and collectively, have an important role to play in supporting domestic reforms both at home and in partner countries. The domestic reform agenda is wide–ranging, but priorities for the EU – with a special focus to the European Low–Income Countries (ELICs) – include enhancing firms' productivity by building internal capacities of firms and providing access to capital and connectivity, with particular attention to the needs of SMEs that can benefit greatly from connecting to the RIS3 of their countries. Improved policy outcomes at the national and multilateral level, and a strong EU leadership can lead to more inclusive GVCs.

With this work we intend to investigate Global Value Chains, focusing the analysis on the peculiarities of their diffusion in various emerging countries, on the strategies adopted by politics to manage the phenomenon and on possible future implications.

First of all, it is necessary to underline how the fragmentation of production chains in separate and distant contexts brings with it numerous implications, having a significant impact on the territories, on the social and cultural reality and on the mentality with which economic relations are understood, also through the creation of opportunities of comparison with mentalities different from one's own and the multiplication of the possibility of accessing new and previously unattainable knowledge.

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Elements such as innovation and the propensity to create collaborations with subjects of a different nature are able to influence the participation of SMEs and their positioning within the Value Chains.

The objective is to provide a detailed description of the various levels of predisposition to internationalization present in the global system, of the different difficulties and shortcomings that must be faced and how the latter vary depending on the environment in which they operate. In this context, it is important not only to understand what type of policies are adopted to act on the phenomenon, but also to understand what types of processes are best suited to address the numerous problems that integration in Global Value Chains implies, as further highlighted by emergency situation created during the Covid-19 pandemic.

2. THE CASE-STUDY OF PHARMACEUTICAL SECTOR IN BRAZIL

Brazil, a nation of diverse landscapes and cultural richness, has witnessed a remarkable economic and societal evolution over the years. In the heart of this transformation lies the pharmaceutical industry, a pivotal player that mirrors the nation's journey from an agrarian economy to a dynamic, diversified force. The pharmaceutical sector in Brazil is not merely a contributor to the nation's economic landscape; it is a strategic pillar that aligns with Brazil's commitment to innovation, healthcare, and sustainable development. As we embark on this exploration of the pharmacy industry in Brazil, it becomes evident that the sector serves as a microcosm of Brazil's resilience, adaptability, and forward-looking aspirations.

Amidst the intricate tapestry of Brazil's economic history, the pharmacy industry has emerged as a beacon of stability and innovation. Brazil's commitment to sustainable practices, technological advancements, and healthcare infrastructure is intricately woven into the fabric of its pharmaceutical landscape. As we delve deeper into the characteristics, contributions, and challenges faced by the pharmacy industry in Brazil, a comprehensive understanding of its role in the nation's past, present, and future unfolds. This report aims to unravel the layers of Brazil's pharmaceutical sector, providing insights into its economic

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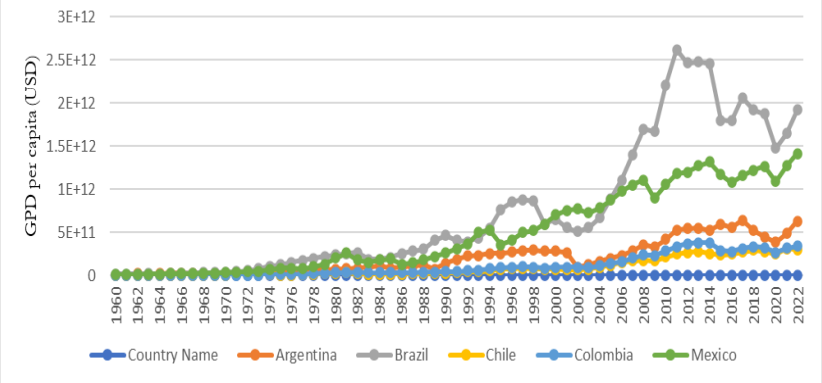
significance, societal impact, and the dynamics that shape its trajectory in a rapidly evolving global landscape.

The Economy of Brazil: An In-Depth Analysis of GDP Trends

The Gross Domestic Product (GDP) serves as a key indicator of a nation's economic health, reflecting the overall value of goods and services produced within its borders. Brazil, as a major player in the global economic landscape, has experienced a complex and dynamic economic history, as evidenced by its GDP trends over the decades. Analyzing the GDP data from 1960 to 2022 provides valuable insights into the economic trajectory of Brazil and the factors that have shaped its growth.

Historical Overview

***Figure 1**:Development of GDP per capita*



***Source:** The World Bank (2022)*

In the early 1960s, Brazil's GDP was characterized by modest figures, reflecting an economy that was finding its footing in a rapidly changing global landscape. However, as the years progressed, Brazil underwent a significant economic transformation, marked by periods of robust growth and occasional challenges. The 1970s saw a substantial surge in GDP, driven by various factors such as industrialization, infrastructure development, and increased global trade. The subsequent decade, however, posed economic

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challenges, with external debt and inflationary pressures impacting Brazil's economic stability. The 1980s and 1990s witnessed efforts to address economic vulnerabilities, including stabilization programs and market-oriented reforms. These initiatives laid the groundwork for Brazil's entry into the 21st century with a more resilient and diversified economy. The early 2000s marked a turning point, with Brazil experiencing consistent GDP growth, driven by a booming agricultural sector, increased commodity exports, and a rising middle class. The country emerged as a key player in the BRICS group, further solidifying its position in the global economy.

Key Trends and Challenges

Examining the GDP data reveals nuanced trends in Brazil's economic landscape. The 1980s debt crisis and the subsequent period of economic stabilization influenced GDP patterns. Brazil's journey through the 1990s, marked by privatization and market-oriented reforms, played a crucial role in shaping its economic structure. The 2000s and early 2010s reflect a period of sustained growth, driven by favorable global conditions and domestic reforms.

However, challenges such as inflationary pressures, fiscal deficits, and external uncertainties have been persistent. The years 2015-2016, in particular, were characterized by economic contractions, reflecting the impact of global economic downturns and domestic challenges. The resilience of Brazil's economy in overcoming these downturns demonstrates its ability to adapt to changing circumstances.

In recent years, Brazil has faced economic challenges, including the impact of the COVID-19 pandemic and fluctuations in commodity prices. Despite these challenges, the GDP data underscores Brazil's resilience and potential for recovery. The diversified nature of its economy, encompassing agriculture, manufacturing, and services, positions Brazil as a multifaceted economic player with the capacity to navigate global economic dynamics.

In conclusion, the analysis of Brazil's GDP data provides a comprehensive understanding of its economic evolution. From the challenges of the 1980s to the growth of the 2000s, Brazil's economy reflects a complex interplay of domestic and global factors. As Brazil

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continues its journey into the future, the resilience demonstrated through its economic history positions it as a key player in the global economic landscape.

Theoretical Concepts

In the field of development economics, the concept of "cathcing up" refers to the process by which relatively less developed countries or regions strive to close the economic gap with more advanced economies (Abramovitz, 1986). Looking back now on the record of more than a century, we can see that catching up was a powerful continuing element in the growth experience of the presently advanced industrial countries (Abramovitz, 1986).
There is a common-held view that the transformation of the world economy since the 1980s has some distinctive features, and that interpreting the so-called rise of global value chains (GVCs) as simply an intensification of trade integration across countries misses several key dimensions of this phenomenon (Pol Antràs, 2020).
The broad conceptualization of the rise of GVCs might suggest that there is nothing fundamentally new about this latest wave of globalization. It just entails more (or deeper) integration across countries, but it is shaped by the same factors as traditional trade áows and it carries largely the same implications. The concept of 'governance' is central to the global value-chain approach. We use the term to express that some firms in the chain set and/or enforce the parameters under which others in the chain operate. A chain without governance would just be a string of market relations (Humphrey and Schmitz, 2001).
Governments can employ various policies to facilitate catching up and promote economic development. One approach is investing in human capital through education and enhancing access to quality healthcare and social services (Kohler-Koch, 1996). Scholars also recognize the importance of technological growth and allocating capital to research and development activities to stimulate innovation and knowledge creation (Radosevic, 1999). Further, the development of infrastructure, such as transportation networks and digital connectivity serve as essential foundations for economic activity and attract private investments (Lall and Narula, 2004).
In the pursuit of catching up, less developed countries find themselves at the intersection

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of opportunity and strategy within Global Value Chains (GVCs). These intricate networks of production, distribution, and value addition serve as a pivotal avenue for economic convergence and sustained growth. The symbiotic relationship between GVCs and the catching-up approach becomes evident as nations strategically position themselves within the global production landscape.

Participation in GVCs opens up a spectrum of possibilities for less developed countries, offering accelerated economic growth, improved productivity, and enhanced competitiveness. By integrating into GVCs, these nations gain access to advanced technologies and knowledge embedded within the value chains, bridging the technological gap and fostering innovation. Simultaneously, GVCs provide a pathway to global markets, expanding export opportunities and overcoming entry barriers.

The catching-up approach, centered around narrowing the economic gap with advanced economies, aligns seamlessly with the requirements for effective GVC integration. Developing economies, as they specialize in specific stages of the value chain, capitalize on comparative advantages such as low-cost labor or specific expertise. This strategic positioning enables them to ascend the value chain gradually, acquiring crucial technological know-how, skills, and access to international markets.

However, realizing the full potential of GVC participation for catching up necessitates supportive policies and institutions. Investments in education and skills development, crucial for cultivating a skilled workforce, are paramount. Infrastructure development, particularly in logistics and transportation, becomes a linchpin for supporting the intricacies of GVCs. Moreover, fostering technological innovation, establishing institutional frameworks, and implementing policies that promote entrepreneurship and value-added activities are essential for a conducive environment.

In essence, the relationship between GVCs and the catching-up approach is symbiotic. GVCs offer a framework through which catching-up economies can tap into global markets, technologies, and expertise, accelerating their economic growth. Simultaneously, the catching-up approach provides the necessary foundation for these economies to effectively participate in GVCs by creating the enabling conditions for value

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addition, innovation, and integration into international production networks. "Catching up along global value chains" encapsulates the dynamic interplay that propels developing nations towards equitable development and global competitiveness.

Structure, Specialization and Policy Mix

The pharmaceutical sector in Brazil has undergone transformative shifts in response to globalization, technological advancements, and evolving consumer demands. Understanding the structural dynamics of the pharmacy industry is paramount for policymakers, healthcare professionals, and industry stakeholders seeking to navigate an increasingly complex landscape. This research embarks on a comprehensive analysis, aiming to unravel the intricate nuances within the Brazilian pharmacy industry. By scrutinizing the interplay of structural dynamics, patterns of specialization, and the policy landscape, we endeavor to provide insights into the industry's adaptability and resilience amidst changing market forces.

The market composition of Brazil's pharmacy industry is characterized by a diverse array of stakeholders, including multinational pharmaceutical giants, local manufacturers, distributors, and retailers. The presence of both international and domestic players influences competition, innovation, and access to pharmaceutical products. This study seeks to evaluate how the industry has evolved over time, identifying key players, market share dynamics, and the regulatory frameworks that govern their operations. By analyzing the structural dynamics, we aim to discern the industry's ability to meet the diverse healthcare needs of Brazil's population and contribute to the broader health outcomes of the nation.

Brazil's pharmacy industry is a complex ecosystem marked by the coexistence of multinational pharmaceutical giants, local manufacturers, distributors, and retailers. This diverse composition significantly influences competition, innovation, and the accessibility of pharmaceutical products. The structural dynamics of the industry are shaped by the intricate relationships among these stakeholders, each playing a unique role in the production and distribution of pharmaceuticals. In Brazil, structuring of the public health

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care system began in 1808. However, the national public health care system (NPHS), known as Sistema Único de Saúde, was created in 1990, through the Federal Constitution and Federal Law 8.080/1990, following a social movement to change the way in which health care was delivered (Paim J et al. 2011) The National Pharmaceutical Policies of 1998, along with Resolution 338/2004, also guaranteed access to medicine through this system. Multinational corporations, leveraging global resources and research capabilities, often dominate certain segments of the value chain. They contribute to the industry's innovation and technological advancement, bringing cutting-edge medicines to the Brazilian market. Conversely, local manufacturers and distributors play a crucial role in addressing specific healthcare needs, ensuring the availability of affordable medications, and fostering domestic economic growth. The market share dynamics within the industry are also influenced by regulatory frameworks governing entry, competition, and pricing. Government policies aimed at promoting fair competition, intellectual property protection, and market transparency impact how companies operate within the pharmaceutical landscape. Understanding these structural intricacies is vital for assessing the industry's capacity to adapt to changing market dynamics, provide diverse healthcare solutions, and contribute to Brazil's overall health outcomes.

The Brazilian pharmacy industry exhibits distinctive patterns of specialization across its value chain, encompassing drug manufacturing, distribution, and retail. This strategic division of labor allows different entities within the industry to focus on specific stages where they can contribute most effectively, fostering efficiency, innovation, and overall sectoral resilience. In drug manufacturing, specialization often revolves around research and development, with multinational corporations at the forefront of pioneering new pharmaceuticals. These entities leverage their global research capabilities to introduce advanced medicines to the Brazilian market. Simultaneously, local manufacturers may specialize in producing generic medications, contributing to the affordability and accessibility of essential drugs. Distribution and retail segments of the value chain witness further specialization, with various entities concentrating on their core competencies. Distribution networks may specialize in efficient logistics, ensuring the timely and reliable

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supply of medications across the vast Brazilian territory. At the retail level, specialization may manifest through diverse business models, including large pharmacy chains, community pharmacies, and online platforms, each catering to specific consumer needs. Understanding these specialization patterns is instrumental in evaluating the industry's adaptability and responsiveness to market demands. It sheds light on how different entities within the pharmacy sector contribute to the overall ecosystem, ensuring a diverse range of pharmaceutical products and services are available to meet the varied healthcare needs of Brazil's population. The intricate dynamics of the Brazilian pharmacy industry, encompassing its structural composition, specialization patterns, and policy landscape, exert profound implications on critical health indicators in the nation. The structural diversity, marked by the presence of multinational corporations, local manufacturers, distributors, and retailers, significantly influences health expenditure. The interplay of these entities within the industry, each contributing distinct expertise and capabilities, shapes the accessibility and affordability of pharmaceuticals, thereby impacting overall healthcare costs in Brazil. Moreover, the specialization patterns within the value chain, from drug manufacturing to distribution and retail, play a pivotal role in determining the range of healthcare services available to the population. This, in turn, has repercussions on life expectancy, as the accessibility of medications and healthcare services contributes to disease management and overall public health outcomes. Additionally, the industry's adaptability to the needs of an aging population, a demographic shift observed in Brazil, is crucial for addressing the unique healthcare requirements of individuals aged 65 and above. Effective policies that govern the industry, reflecting an understanding of its structural nuances and specialization patterns, are fundamental in shaping a healthcare landscape that supports longevity, addresses diverse healthcare needs, and optimizes health expenditure for sustainable and equitable outcomes.

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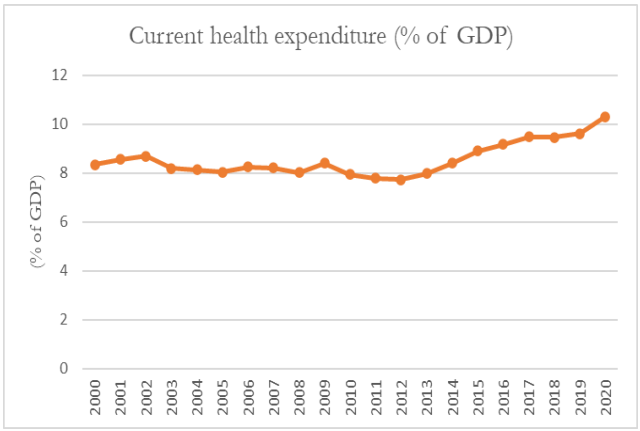
Figure 2: *Health Expenditure in Brazil*



Source: *The World Bank (2022b)*

Brazil's commitment to healthcare is evident in the data on current health expenditure as a percentage of GDP. Over the years, the allocation of resources to the healthcare sector has shown both stability and fluctuations, indicating the dynamic nature of the nation's healthcare priorities. In 1960, Brazil's health expenditure represented 8.33% of its GDP, a proportion that increased gradually over the following years, reaching 10.31% in 1986. Subsequently, there was a period of decline, reaching a low of 7.74% in 1992. The data reflects a recovery and upward trajectory in the late 1990s, peaking at 10.31% in 2002. However, it should be noted that the percentage has seen a general decline since then, standing at 8.91% in the most recent data. Today, the Brazilian population is experiencing a double burden of disease, related to both noncommunicable and communicable diseases. As the epidemiological transition begins, noncommunicable diseases are starting to replace communicable diseases; however, infectious conditions continue to be highly prevalent in the country (Borges MC el al. 2016). The fluctuations in health expenditure as a percentage of GDP suggest a complex interplay of economic, social, and political factors influencing budgetary decisions. While the increase in the early 2000s could be associated with efforts to strengthen the healthcare system, the subsequent decline might reflect competing fiscal priorities or improvements in the efficiency of

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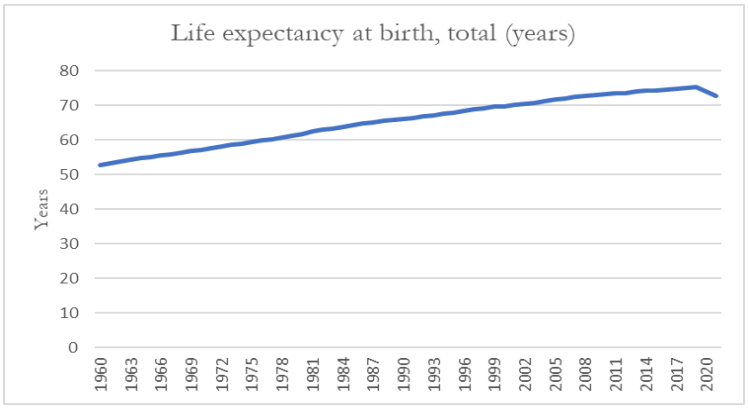
healthcare spending. Understanding these trends is crucial for evaluating the stability and resilience of Brazil's healthcare system, which, in turn, plays a pivotal role in shaping the pharmaceutical landscape. A robust healthcare infrastructure often correlates with increased demand for pharmaceutical products, making it a key consideration for stakeholders in the pharmaceutical industry.

Figure 3: *Life expectancy in Brazil*



Source: *The World Bank (2022b)*

Life expectancy at birth is a critical indicator of a nation's overall health and well-being. Brazil's life expectancy data, spanning from 1960 to the most recent available year, paints a compelling picture of the country's demographic evolution. In 1960, life expectancy at birth stood at 52.66 years, reflecting the health conditions and challenges of that era. Over the subsequent decades, Brazil witnessed a consistent upward trend in life expectancy, indicating improvements in healthcare, living standards, and overall societal conditions.
By 2022, life expectancy at birth had reached 72.75 years, a remarkable increase over the past six decades. This upward trajectory is indicative of successful public health interventions, medical advancements, and improvements in living standards. The steady rise in life expectancy aligns with global trends associated with socio-economic development, healthcare accessibility, and advancements in medical science. However, the observed fluctuations in certain years underscore the impact of external factors, such

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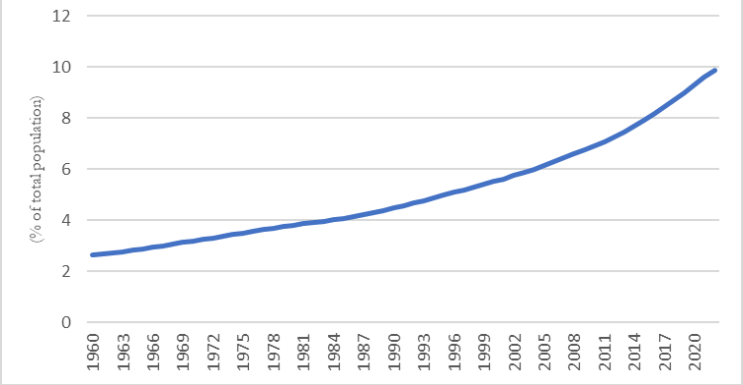
as disease outbreaks, economic crises, or social challenges, on public health outcomes. For stakeholders in the pharmaceutical industry, understanding the demographic landscape, as reflected in life expectancy data, is crucial for anticipating and meeting the healthcare needs of an aging population. Longer life expectancies often correlate with increased healthcare demands, particularly for pharmaceutical products addressing age-related conditions and chronic diseases. As Brazil continues to experience demographic shifts, the pharmaceutical sector must align its strategies with the evolving health profile of the population.

Figure 4: *Population ages 65 and above*



Source: *The World Bank (2022b)*

The demographic landscape of Brazil is undergoing a significant transformation, evident in the population ages 65 and above (% of total population) data. Over the years from 1960 to 2022, there has been a discernible increase in the proportion of elderly individuals in the total population. In 1960, the percentage of the population aged 65 and above was 2.63%, and this figure has steadily risen, reaching 9.88% by 2022. This demographic shift reflects improvements in healthcare, living conditions, and overall well-being, contributing to an aging population. The continuous growth in the elderly population has important implications for various sectors, particularly healthcare and pharmaceuticals. As people age, there is an increased demand for healthcare services and pharmaceutical products to address age-related health issues. Chronic conditions, prevalent among the elderly,

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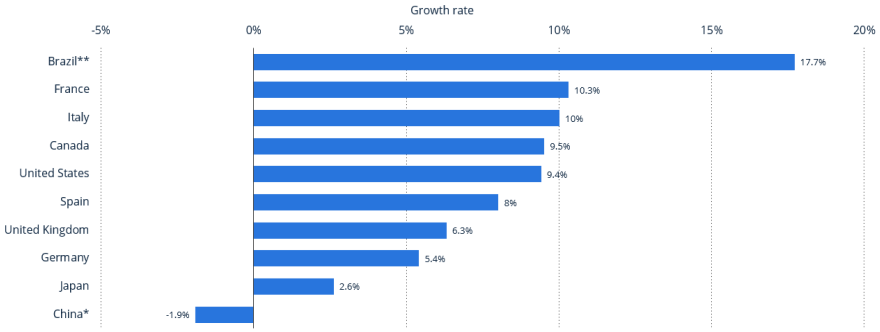
often require ongoing medical attention and pharmaceutical interventions. For the pharmaceutical industry in Brazil, this demographic trend underscores the importance of developing and providing medications that cater to the specific health needs of an aging population. Furthermore, the data on the population ages 65 and above provides valuable insights for policymakers and healthcare planners. Understanding the proportion of elderly individuals in the population helps in anticipating future healthcare requirements, planning for healthcare infrastructure, and designing public health initiatives that address the unique needs of the elderly. It also emphasizes the importance of promoting healthy aging and disease prevention strategies to ensure a higher quality of life for the elderly population in Brazil.

Modelling Approach, Empirical Analysis and Case Study Techniques

Figure 5: *Growth rate of top 10 national pharmaceutical markets worldwide in 2022*



Source: *www.statista.com*

The pharmaceutical industry in Brazil has witnessed significant growth, with a market share of 1.9% globally in 2022. While the United States commands a dominant position with a 42% market share, Brazil's pharmaceutical sector stands out with a remarkable growth rate of 17.7%, positioning it as a noteworthy player on the international stage. The growth is attributed to factors such as a large and diverse population, improvements in healthcare infrastructure, and a focus on research and development. Despite facing

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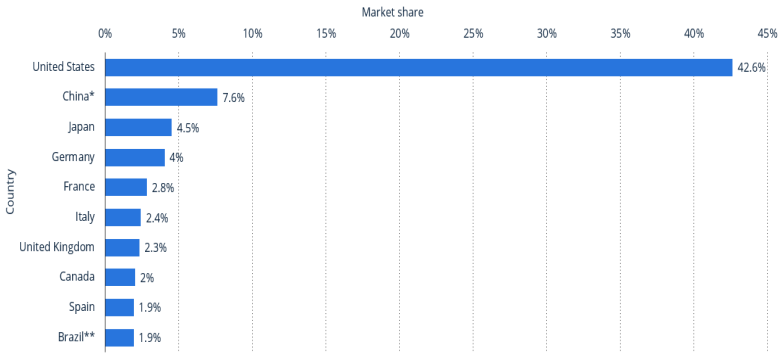
challenges such as regulatory complexities, Brazil's pharmaceutical industry presents ample opportunities for innovation and collaboration to meet the evolving healthcare needs of its population.

Figure 6: *Market share of leading 10 national pharmaceutical markets worldwide in 2022*



Source: *www.statista.com*

In comparison to other top national markets, Brazil's growth rate surpasses that of major players like France, Italy, and the United States in 2022. France and Italy exhibited growth rates of 10.3% and 10%, respectively, while the U.S. experienced a growth rate of 9.4%. Brazil's ascent in the pharmaceutical landscape underscores its potential as a key destination for pharmaceutical investments. As the industry continues to evolve, addressing regulatory challenges and leveraging strategic partnerships will be crucial for sustaining the positive momentum and further establishing Brazil as a significant player in the global pharmaceutical market. The Catch-Up Performance Index (CUPI) is a statistical measure used to assess a country's progress in catching up with more advanced economies in terms of income or economic development. It is a commonly used index in the field of economics to evaluate how well a country is narrowing the income gap or "catching up" with a reference country or group of countries. In this report, we define the CUPI index as follows:

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$$CUPI_{0,T}^{i} = ln\left[\frac{rel\_y_T^i}{rel\_y_0^i}\right]/T$$

In this formula, $rel\_y_T^i$ is the relative difference between the pharmaceutical sales revenue between Brazil and the US at year T, while $rel\_y_0^i$ is the same difference but at the base year. By definition, $CUPI_{0,T}^{i} > 0$ if country is catching up ($rel\_y_T^i > rel\_y_0^i$), $CUPI_{0,T}^{i} < 0$ if it is falling behind ($rel\_y_T^i < rel\_y_0^i$), and $CUPI_{0,T}^{i} = 0$ if it is neither catching up nor falling behind ($rel\_y_T^i = rel\_y_0^i$).

Figure 7: *CUPI Index for Brazil*

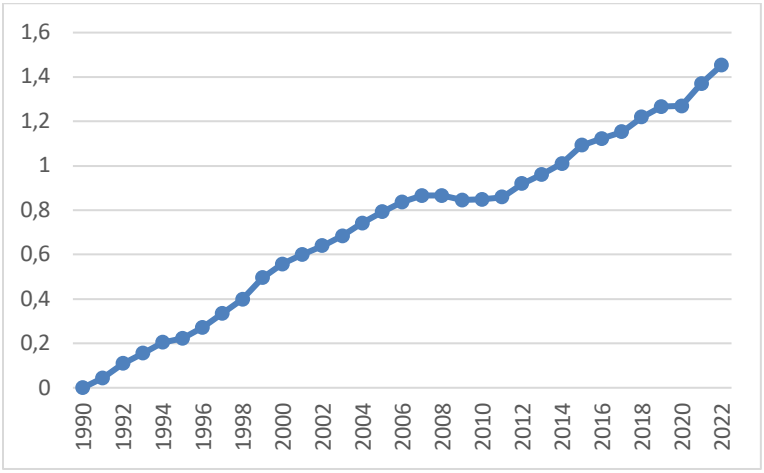
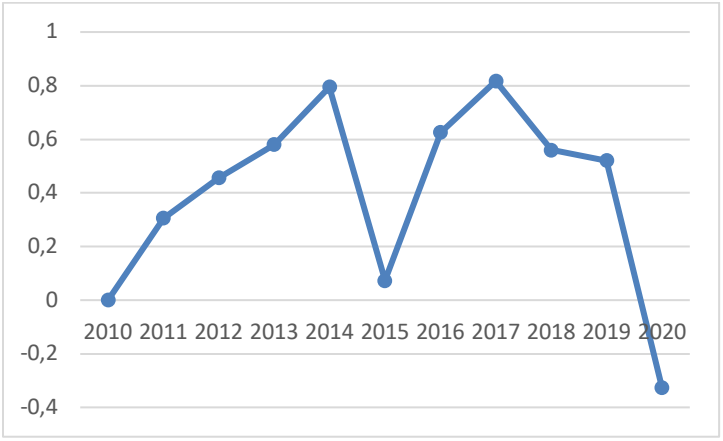


Figure 8: *SCUPI Index for Brazil Pharmaceutical Sector*



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Conclusion

In summation, the intricate landscape of the Brazilian pharmacy industry, as examined through the lenses of structural dynamics, specialization patterns, and policy frameworks, is integral not only to the nation's health outcomes but also to its positioning within the global context. The industry's diverse composition, featuring both multinational and local entities, reflects its participation in global value chains (GVCs). Through strategic specialization, Brazil aligns itself with the international division of labor, contributing distinct expertise to the pharmaceutical value chain. The industry's adaptability and resilience, crucial for catching up within global value chains, are evident in its response to evolving market forces and healthcare needs. As Brazil's pharmacy sector navigates the challenges and opportunities of globalization, it concurrently influences critical health indicators. The connection between the pharmacy industry and health expenditure underscores the broader economic implications of participating in global value chains, as efficient and innovative healthcare systems contribute to sustainable economic growth. Moreover, the industry's role in shaping healthcare outcomes is vital for Brazil's pursuit of catching up along global value chains. The structural diversity and specialization patterns within the pharmaceutical sector directly impact life expectancy and address the healthcare requirements of an aging population.

Effective policies that govern the industry not only optimize health expenditure but also position Brazil competitively within global value chains, fostering innovation, efficiency, and global competitiveness. In essence, the Brazilian pharmacy industry serves as a microcosm of the nation's endeavors to catch up within global value chains. By recognizing and harnessing its structural nuances, fostering strategic specialization, and implementing effective policies, Brazil can not only enhance its healthcare landscape but also position itself competitively on the global stage, contributing to the collective pursuit of equitable development and sustained growth.

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3. THE CASE-STUDY OF AGRICULTURE SECTOR IN COSTA RICA

Situated in the diverse Central American Region, Costa Rica is a success story of a country that has lifted its economic wealth while remaining committed to the preservation of its natural wealth. With its favorable climate, Costa Rica has historically relied on the production and export of crops as an important source of income. However, as the country seeks to advance its economy, there are indications that agriculture will play a less important role in future. Departing from this trend, we examine the characteristics of Costa Rica's agriculture sector and the potential avenues through which it can adapt to a changing economy.

The economy of Costa Rica

Costa Rica is a success story in a geographical region that, despite its natural and cultural beauty, has been haunted by its colonial past, political instability, and crime. Part of the Costa Rica's prosperity can be attributed to the development of strong political institutions. After becoming independent from Spain in 1821, the country experienced a relatively early transition to democratic governance compared to other Central American countries. Combined with a strong civil society, the decision to abolish the military in 1949 set Costa Rica on a unique path, free from military coups or interventions, allowing for peaceful political processes.

In addition to strong institutions, liberal trade policies and investments in education, healthcare and infrastructure paved the way for the influx of foreign investments, driving economic growth. As evident from Figure 1, Costa Rica's GDP per capita was similar to other countries in Central America during the 1970's and 80's but has taken off since the 2000s. As of 2022, the country's GDP is 67% higher than the average of the region ($13,199 vs $7905) (The World Bank, 2022a).

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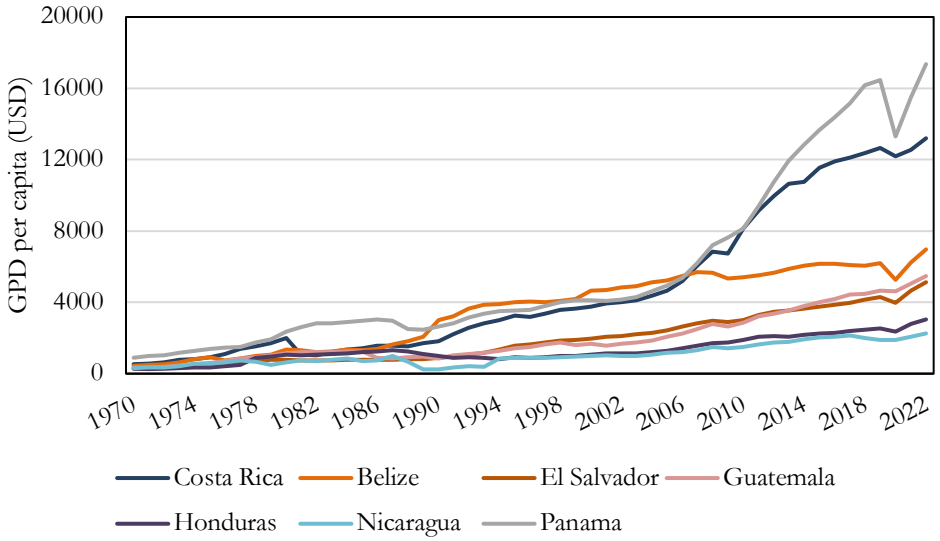
Figure 9: *Development of GDP per capita in Central America (1970 – 2022)*



Source: *The World Bank (2022a)*

Costa Rica's economy has undergone a remarkable transformation throughout the past 50 years. Historically, the economy specialized in the production of coffee and bananas, reflecting its colonial legacy and the abundance of arable land. The focus has since shifted away from the primarily agricultural-based economy towards one that encompasses a diverse range of sectors, such as tourism, technology outsourcing and professional services. This transformation has been driven by factors such as globalization, technological advancements, and a commitment to sustainable practices.

Costa Rica's movement towards service industries has been particularly evident since the 2000s. As seen from Figure 2, the contribution of the information, professional and financial services sectors to GDP increased substantially between 2000 and 2022. During the period, information services increased with 434%; professional services increased with 161%; and financial services increased with 157%. Meanwhile, primary sectors (agriculture) and secondary sectors (manufacturing and construction) have decreased significantly. From 2000 to 2022, the share of GDP generated by agriculture fell from 7.0% to 4.5%. Similarly, manufacturing and construction decreased from 19.3% to 14.5% and from 5.2% to 3.9%, respectively.

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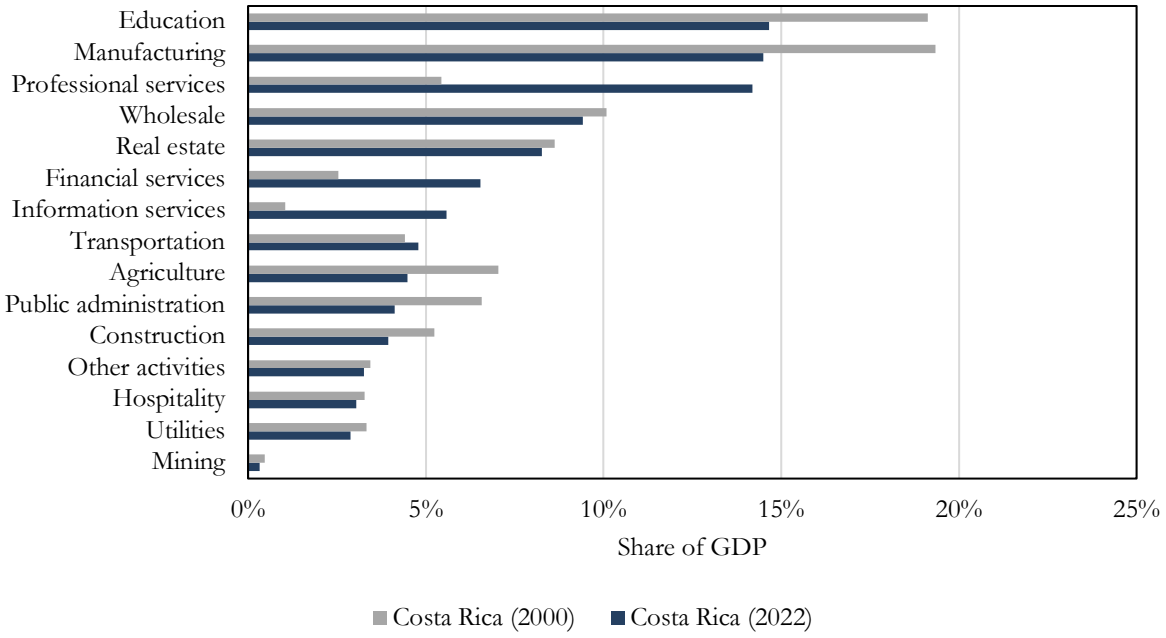
Figure 10: *Development in the share of GDP by economic sector (2000 – 2022)*



Source: *Costa Rica National Bank (2022)*

The Agricultural Sector

The agriculture sector, which is the focus of this report, is characterized by a dynamic blend of small-scale farmers and larger-scale producers, each shaping the agricultural landscape. The commitment to sustainable practices and the preservation of biodiversity has earned Costa Rican farmers international recognition. These efforts have contributed to growing the absolute value of the sector by 43% from 2000 to 2022 as evident from Figure 3. However, the sector's relative share of the country's GDP decreased consistently throughout the period. This development reflects a systematic change in the composition of the economy as Costa Rica deliberately attempts to diversify the economy and expand into more lucrative sectors.

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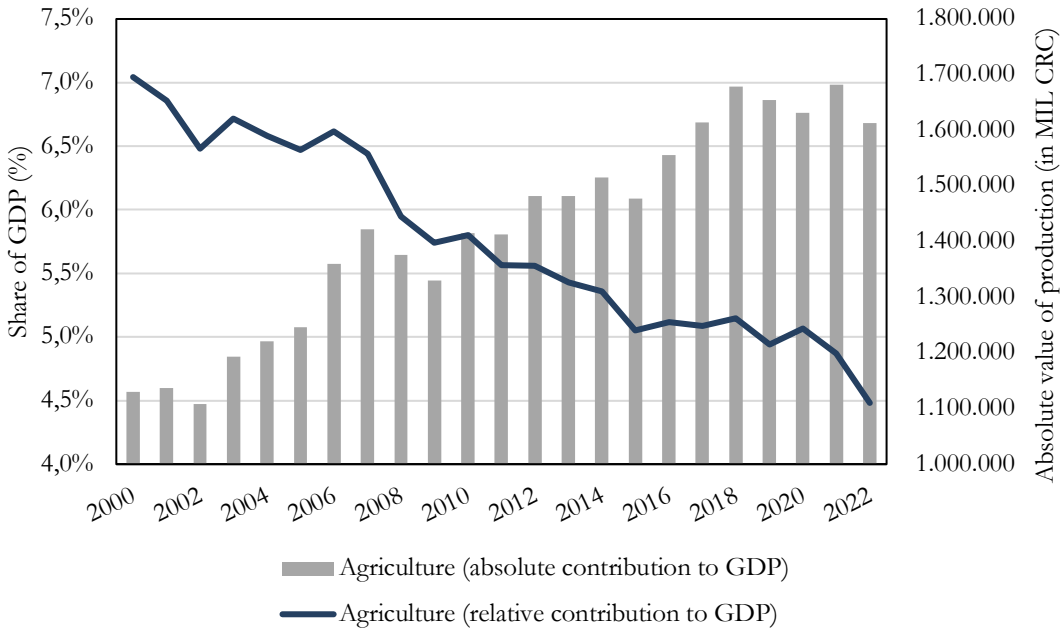
Figure 11: *The contribution of the agricultural sector to Costa Rica's GDP (2000 – 2022)*



Source: *The World Bank (2022b)*

Furthermore, agriculture plays a less prominent role in Costa Rica's economy compared to most other countries in the Central American region. The neighbor to the north, Nicaragua, is more dependent on agriculture than any other country in the region with 17% of GDP generated by this sector. In contrast, Costa Rica's southern neighbor, Panama, has with its strategic geography specialized in shipping, logistics and banking and now only generates 3% of its GDP from agriculture.

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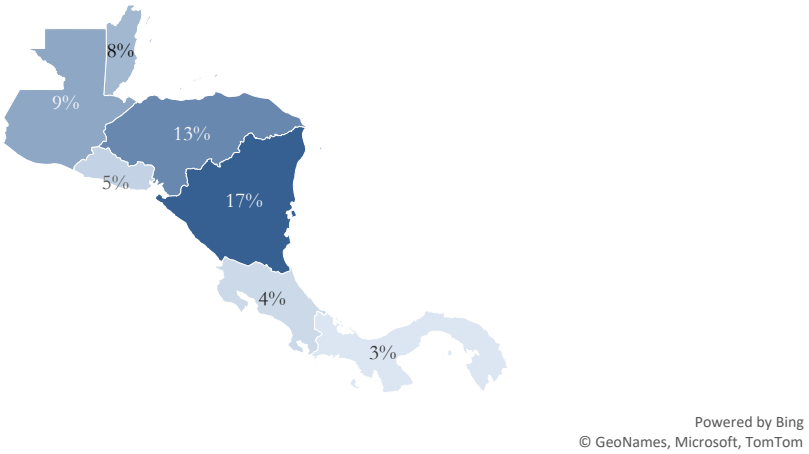
Figure 12: *Share of GDP from agriculture, forestry, and fishing (2022)*



Source: *The World Bank (2022b)*

Despite losing its relative importance for Costa Rica's economy, the agricultural sector continues to employ 14% of the labor force and accounts for 34.5% of land use (The World Bank, 2022c). The role of the sector also extends its economic contributions, encompassing aspects of environmental conservation, food security, and rural development. As such, we examine the role of the agriculture sector as Costa Rica continues to develop and catch up with more developed nations. The remaining part of the report is organized as follows: Section 2 introduces the theoretical concepts of catching up and global value chains. Section 3 discusses Costa Rica's specialization and policy mix. Section 4 introduces the empirical approach to the analysis. Section 5 presents a deep analysis of the agriculture sector in Costa Rica. Section 6 concludes.

Theoretical Concepts

In the field of development economics, the concept of "cathcing up" refers to the process by which relatively less developed countries or regions strive to close the economic gap with more advanced economies (Abramovitz, 1986). The concept is often associated with the idea of "convergence", where less developed economies grow at faster rates than

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developed economies, leading to a narrowing of the gap over time. Convergence can be observed in different sectors and indicators, such as per capita income, industrial productivity, education, healthcare, and technological innovation.

Catching up is a complex and multifaceted endeavour that presents several challenges. One of the primary hurdles is overcoming the vast technological and knowledge gaps that exist between developed and developing economies. Acquiring advanced technology and knowledge requires substantial investments in research and development, education, and infrastructure, which can strain limited resources and hinder progress (Radosevic, 1999). Additionally, catching up often involves navigating the complexities of global markets, where established competitors already hold significant market share and possess well-established networks (Shin, 2013). Overcoming institutional and governance deficiencies, such as corruption and bureaucratic inefficiencies, is another critical challenge that emerging economies face when trying to catch up (Keefer and Knack, 1997). Along with geopolitical uncertainties, environmental sustainability concerns, and social inequalities, these factors compound the challenges of catching up.

Governments can employ various policies to facilitate catching up and promote economic development. One approach is investing in human capital through education and enhancing access to quality healthcare and social services (Kohler-Koch, 1996). Scholars also recognize the importance of technological growth and allocating capital to research and development activities to stimulate innovation and knowledge creation (Radosevic, 1999). Further, the development of infrastructure, such as transportation networks and digital connectivity serve as essential foundations for economic activity and attract private investments (Lall and Narula, 2004).

The concept of global value chains (GVCs) refers to the interconnected network of production activities and processes that span across multiple countries and firms (Gereffi et al., 2005). It represents the international division of labour, where different stages of a product's creation, manufacturing, and distribution are dispersed across various geographic locations. GVCs capture the complex and dynamic nature of today's globalized economy, where countries and firms specialize in specific tasks within the value chain to

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maximize efficiency and take advantage of their comparative advantages (Kano et al., 2020).

In a global value chain, production processes are fragmented, with different countries specializing in specific stages of the value chain (Humphrey and Schmitz, 2001). This fragmentation allows for the optimization of resources and expertise, as each country or firm focuses on the tasks they can perform most efficiently and cost-effectively. For example, one country may specialize in research and development, another in component manufacturing, and yet another in final assembly. This division of labour creates interdependencies and linkages among firms and countries, forming a web of collaborative relationships.

Global value chains (GVCs) play a vital role in the catching-up process for less developed countries. Participation in GVCs offers a range of opportunities for these countries to accelerate their economic growth, improve productivity, and enhance their overall competitiveness (Fagerberg et al., 2018). Firstly, integration into GVCs allows them to gain access to advanced technologies and knowledge that are embedded within the value chains. By collaborating with more advanced economies and multinational corporations, they can learn from established practices, acquire valuable technological capabilities, and bridge the technological gap. This transfer of knowledge and technology fosters innovation, promotes productivity improvements, and enables catching up.

Secondly, GVCs provide a pathway for less developed countries to access global markets and expand their export opportunities. By becoming part of the value chains, these countries can tap into larger consumer bases, benefit from the scale and scope of international trade, and overcome barriers to market entry (Rodrik, 2018). Integration into GVCs facilitates market integration, diversification of exports, and the development of global business relationships.

Thirdly, participation in GVCs encourages less developed countries to enhance their productivity and efficiency levels (Rodrik, 2018). As they specialize in specific stages of the value chain where they have a comparative advantage, they can focus on activities that align with their strengths. This specialization and division of labour enable them to

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achieve economies of scale, improve operational efficiency, and enhance productivity. By continuously upgrading their capabilities, adopting more advanced technologies and processes, and improving the quality of their products and services, these countries can narrow the productivity gap with more advanced economies and position themselves competitively in the global market.

However, realizing the potential benefits of participating in GVCs for catching up requires supportive policies and institutions. Governments of less developed countries should prioritize investments in education and skills development to cultivate a skilled workforce that can effectively engage in value chain activities (Kohler-Koch, 1996). Infrastructure development is crucial to support logistics, transportation, and connectivity requirements (Harmatuck, 1996). Furthermore, fostering technological innovation, establishing institutional frameworks, and implementing policies that promote entrepreneurship and enable local firms to move up the value chain are essential. Ensuring an enabling environment that supports GVC participation and actively promoting the development of domestic industries and value-added activities can further enhance the catching-up process.

Structure, Specialization and Policy Mix

Costa Rica's agriculture presents a diverse and dynamic landscape, where various farming models coexist. Small-scale farmers play a crucial role, especially in growing staple crops like corn, beans, rice, and sugarcane (Cole, 2010). They contribute to the country's food security and preserve traditional farming practices rooted in Costa Rican culture. On a larger scale, agribusinesses and multinational corporations take the stage, focusing on export-oriented crops like bananas, pineapples, coffee, and ornamental plants. These products cater to international markets and highlight Costa Rica's ability to meet global demand. This balance between small-scale subsistence farming and large-scale export-oriented agriculture ensures both domestic needs and economic growth through international trade are met.

The industrial specialization in Costa Rica represents a strategic development of the

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country's agricultural sector, aimed at increasing the efficiency and competitiveness of agricultural production. This trend towards specialization is reflected at all levels including cultivation, processing, and international trade.

Firstly, Costa Rica has achieved excellence in the cultivation of specific agricultural products. For example, there are several coffee-producing regions within the country, each of which has a reputation for its specific terroirs and cultivation methods (Smith, 2018). This specialization has made Costa Rica's coffee popular on the international market and often considered one of the finest in the world. That is mainly because Costa Rica strategically concentrates on cultivating and producing specific agricultural products that align with its natural advantages. Besides, these agro-industrial specializations in Costa Rica have been supported by domestic and foreign investment, particularly in agricultural technology and infrastructure. International agencies and private businesses have invested in the country to support the adoption of modern agricultural practices. Those investments included advanced irrigation systems, new agricultural machinery, and the application of information technology to improve the efficiency and sustainability of agricultural production.

Secondly, industrial specialization is not limited to the production of agricultural products but also includes subsequent processing. Costa Rica has a growing agro-processing industry that includes the roasting of coffee, the packing and freezing of fruits, and other processing segments. The development of such value chains creates more jobs, adds value to agricultural products, and improves competitiveness in both domestic and international markets. Such agro-industrial specialization encourages the development of value chains for agricultural products, providing diversified sources of income.

Thirdly, Industrial specialization is also reflected in international trade. The specialized cultivation and processing of Costa Rica's agricultural products have made these products very attractive in international markets. At the same time, the Costa Rican government's active policy support and international cooperation also play a key role in promoting international trade. To be specific, the Government collaborates with international organizations and trading partners to ensure product quality and safety (Spilker et.al,

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2016), promote market diversification for agricultural products, and provide market access support. This collaboration has helped to expand Costa Rica's trading partners and bring its agricultural products to more international markets.

Because of the importance of agriculture, the government has implemented various policies to support the agricultural industry. These policy mixes include three areas, namely, natural-environment protection, trade promotion, and productivity improvement.

For environmental protection, Costa Rica has made efforts to promote sustainable agriculture practices, including organic farming and environmentally friendly techniques (Kurukulasuriya and Rosenthal, 2013). To be specific, Costa Rica's National Development Plan (2019-2022) outlines key agricultural sustainability priorities, including the conservation of biodiversity in ecosystems outside of the State's natural heritage, the promotion of water security in response to climate change, and efforts to achieve a carbon-neutral economy. Besides, Costa Rica's National Climate Change Adaptation Policy (2018-2030) and the National Decarbonization Plan (2018-2050), along with specific initiatives like NAMA coffee, NAMA livestock, NAMA sugarcane, and NAMA Musaceae (banana), are all aligned with the country's agricultural sector. These policies and initiatives are designed to strengthen the nation's agricultural model by integrating effective approaches from existing strategies. Costa Rica has further advanced this effort by creating the National Low Carbon Livestock Strategy, the National Low-emission Coffee Strategy, and the Low Carbon Banana Strategy, all aimed at minimizing risks and vulnerabilities within these agricultural value chains. 1

For trade promotion, Costa Rica has entered into various trade agreements, including the Central America-Dominican Republic Free Trade Agreement (CAFTA-DR), the Canada-Costa Rica Free Trade Agreement (CCRFTA), and so on (Spilker et al., 2016),. These agreements have had an impact on the agricultural sector by opening up new markets and increasing competition.

For productivity improvement, one big challenge for Costa Rica’s Agriculture is that Access

[1] Source: FAO (Food and Agriculture Organization of the United Nations), https://www.fao.org/in-action/scala/countries/costa-rica/en

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to financing and market opportunities remains difficult for small-scale farmers, who often face limited bargaining power and struggle to reach global markets (Penrose-Buckley, 2007). The government has implemented various policies to support its smallholder farmers. These measures include providing access to credit, offering technical assistance and training programs, establishing market linkages, and offering subsidies and incentives for sustainable farming practices. Additionally, policies focus on land tenure and property rights to secure farmers' land holdings and provide access to crop insurance programs to protect them from losses. These initiatives collectively aim to strengthen the resilience and competitiveness of smallholder farmers in Costa Rica's agricultural sector, enabling them to improve their productivity and income while contributing to sustainable agricultural practices.

Modelling Approach, Empirical Analysis and Case Study Techniques

In order to conduct our analysis, we make use of two main datasets, and a number of minor datasets.

Firstly, we use the data available from the well-established World Bank Group which includes all the major macroeconomic indicators of the country. Moreover, it enables us to look at a detailed set of indicators measuring the development of the countries examined. Secondly, we take advantage of the UN's FAOSTAT. Maintained by the Food and Agriculture Organization (FAO) of the United Nations, this dataset stands as an indispensable resource for agricultural research. FAOSTAT is a comprehensive global repository of agricultural data, encompassing an extensive array of statistical information related to agriculture, food production, and rural development. While its scope extends far beyond Costa Rica's borders, FAOSTAT provides essential insights into the nation's agricultural sector by offering access to historical and contemporary data on crop production, livestock, trade in agricultural products, and other vital indicators. By leveraging FAOSTAT's wealth of data, researchers can thoroughly analyze agricultural landscapes, identify trends, assess productivity, and gain a nuanced understanding of the sector's contributions to the national economy and its role in addressing global challenges

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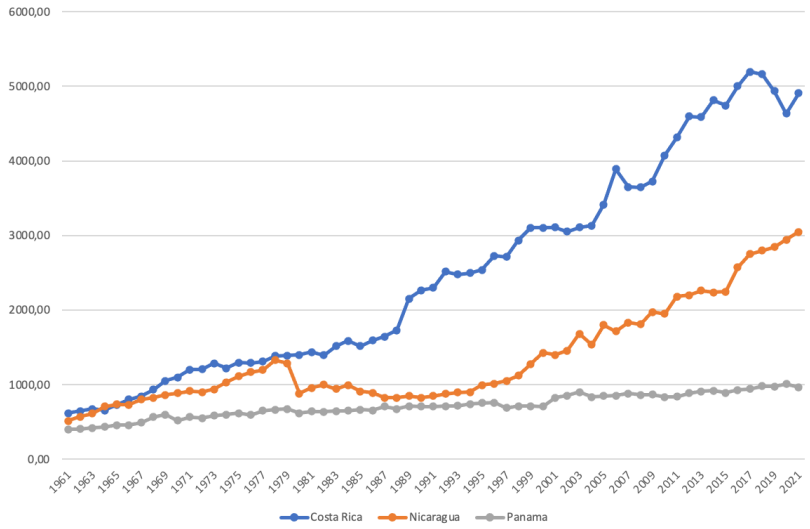
such as food security and sustainability.

However, one shortcoming of this dataset is that it only provides data at the Admin 0 level (Country level), therefore, not giving us an insight into the performance of difference provinces of Costa Rica. However, in this analysis, we only focus on different agricultural sectors at the macro and country level. Nonetheless, in case researchers need to examine Admin 1 level data and look at individual provinces, they can use the data provided by the Agricultural Ministry of Costa Rica.

On the other hand, we also make use of other datasets such as the data collected from CONARES (Consejo Nacional de Rectores), the National Council of Rectors in Costa Rica. As the governing body overseeing higher education institutions in Costa Rica, CONARES plays a crucial role in accrediting and maintaining educational standards across universities and colleges, while providing educational data that we have used in the next chapter.

Using these datasets, particularly the first one, we analyze Costa Rica's agricultural sector performance compared to its two neighbors, Panama and Nicaragua.

Figure 13: *Total Agrticultural Value (constant 2014-2016 million US$)*



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As can be seen from the above plot, extracted from FAOSTAT's data, we can see that in the middle of the 20th century, the total value of Costa Rica's agricultural output was on par with its neighbors, and even behind Nicaragua.

However, as can be seen from the plot, at 1979, the production output of Nicaragua fell sharply which coincides with the overthrow of the Somoza government in the middle of the Nicaraguan Revolution. Nicaragua did not recover from the collapse until the end of the century which allowed Costa Rica to widen the output gap and increase its production value to two third higher than Nicaragua. This is also reflected in their relative GDP per Capita figures and the ongoing social and demographic crisis experienced in Nicaragua.

On the other side, Panama's agricultural output has remained stagnant despite their huge economic growth that was mentioned in the previous section. This leaves Costa Rica as the dominant agricultural power relative to its two major neighbors. However, Costa Rica has also experienced setbacks in its agricultural sector value at mainly two points in time. First, its output was hit hard during the 2008 financial crisis as again can be seen from the plot. Additionally, the value of the sector was hit hard again in 2018, which was then exacerbated by the Covid-19 pandemic. This second fall could be due to the outbreak of African Swine Fever that affected global trade regulations and also supply chains. However, since there were no major reports of this fever in Costa Rica itself, this is something that has to be further studied.

Looking at the subsectors, we can see the following plot, extracted the FAOSTAT database.

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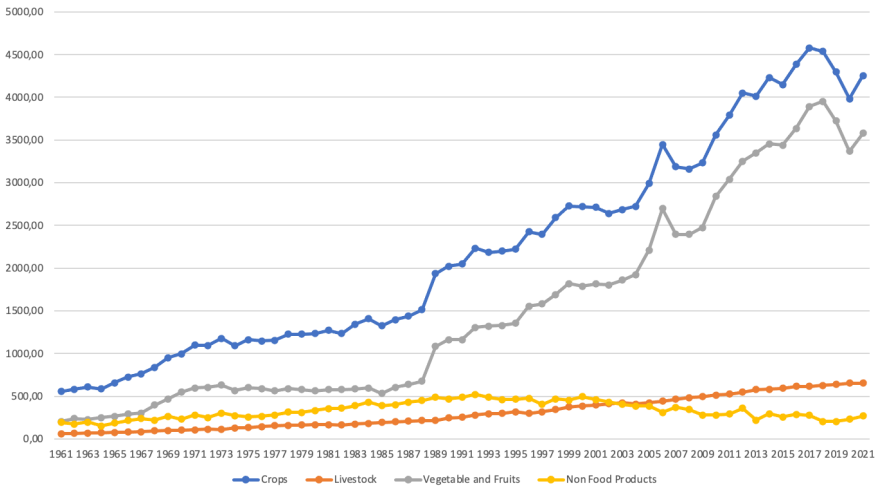
Figure 14: *Different Agricultural Sectors in Costa Rica*



This plot shows that the majority of the growth experienced in the agriculture sector, could be attributed to Crops, and Vegetables and Fruits. However, these two sectors were both hit at the same time during the two periods mentioned before.

Next, we look at the country's CUPI index. The Catch-Up Performance Index (CUPI) is a statistical measure used to assess a country's progress in catching up with more advanced economies in terms of income or economic development. It is a commonly used index in the field of economics to evaluate how well a country is narrowing the income gap or "catching up" with a reference country or group of countries, often the United States. In this report, we define the CUPI index as follows:

$$CUPI_{0,T}^{i} = ln\left[\frac{rel\_y_T^i}{rel\_y_0^i}\right]/T$$

In this formula, $rel\_y_T^i$ is the relative difference between the per capita level of income between Costa Rica and the US at year T, while $rel\_y_0^i$ is the same difference but at the base year.

By definition, $CUPI_{0,T}^{i} > 0$ if country is catching up ($rel\_y_T^i > rel\_y_0^i$), $CUPI_{0,T}^{i} < 0$ if it is falling behind ($rel\_y_T^i < rel\_y_0^i$), and $CUPI_{0,T}^{i} = 0$ if it is neither catching up nor falling behind ($rel\_y_T^i = rel\_y_0^i$).

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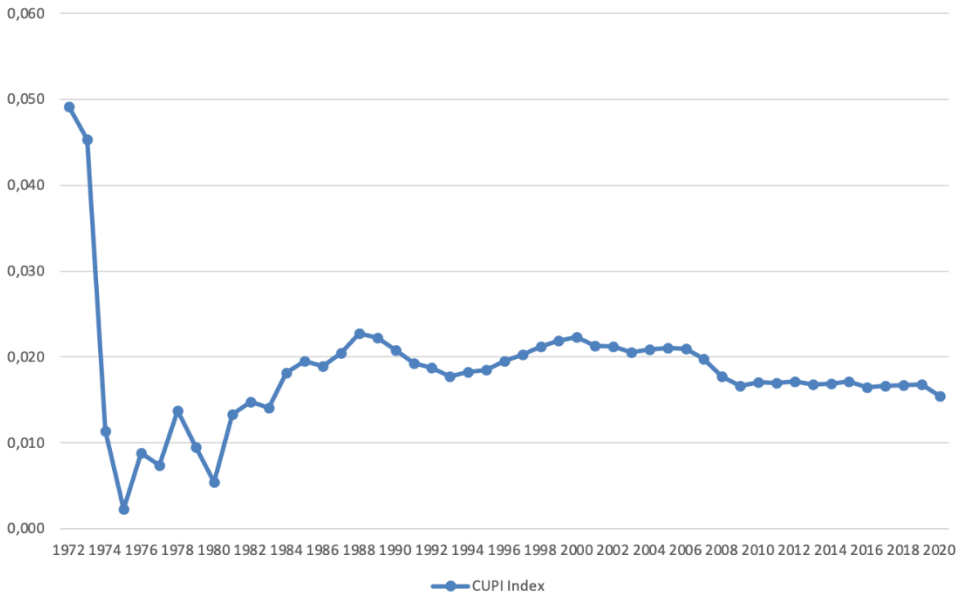
In our analysis, we use the World Bank Development Indicators (WDI) dataset to compute the CUPI over a twenty-year period (1995–2015) for all countries with available data on per capita income (measured in PPP US$ at constant prices).

Figure 15: *CUPI Index for Costa Rica*



Factoring out the first few years as outliers due to their chronological proximity to the base year, we can see that Costa Rica has been constantly narrowing the income gap with the US, despite the US's exceptional economic growth in the same period. However, this improvement in the relative income levels is too slow at around 0.02 which is prolonging the catching-up process. However, at the same time, this positive number reflects robust and stable economic growth and development.

It is mostly believed that the two main drivers of this economic growth have been the agriculture sector, and tourism. Therefore, it is worth going deeper into the SCUPI index and observing the income levels and the value generation in this specific sector compared with the US, using the same formula and the FAOSTAT dataset.

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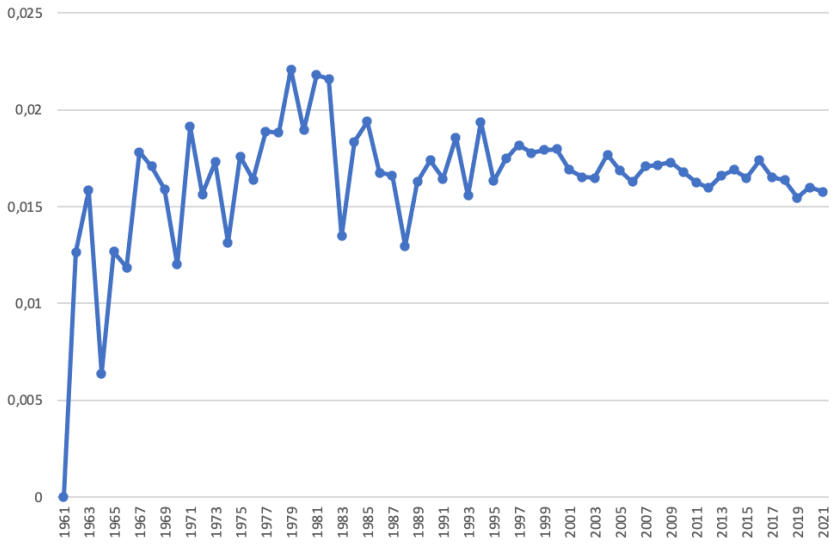
Figure 16: *SCUPI Index for Costa Rica's Agriculture Sector*



Looking at this graph, we can observe that the agriculture sector has also been reducing its relative difference with the US agriculture sector, a feat that considering the robust American agriculture sector, is an achievement. As was also the case with the whole country, we can see that this index hovers just below 0.02, and is relatively stable over time, showing a consistent and sustained growth in the sector. However, we can see that this index is comparatively lower than the CUPI which could be explained by an even stronger growth in other sectors, that are driving the income growth.

This is a very interesting observation as it can support the notion that Costa Rica's economic growth was not only driven by its agriculture sector, as relative to the American economy, other sectors in Costa Rica's economy have also contributed to narrowing the gap between the levels of income. This is exceptionally interesting as the main driver of the American economy in the previous decades has not been its agriculture sector, which makes it harder for other sectors in Costa Rica to contribute to this positive level of CUPI.

All in all, we could say that Costa Rica's CUPI is increasing, as is the SCUPI in the agriculture sector, however, the speed with which this income gap is narrowing is still not as high as it could be.

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Deep Analysis of the Agriculture Sector

Before Costa Rica's remarkable catching-up journey, its agricultural sector existed within a framework shaped by traditional practices and limited modernization. The pre-catching-up era of the agricultural sector laid the groundwork for the transformation that was to come. Features can be summarized as below:

1. Subsistence Farming

In the pre-catching-up phase, Costa Rica's agricultural sector was primarily characterized by subsistence farming. Small-scale farmers focused on cultivating staple crops such as corn, beans, and rice to meet local consumption needs. This approach emphasized self-sufficiency and basic sustenance rather than commercial trade or market-oriented production.

2. Lack of Infrastructure and Export Focus

Limited infrastructure further constrained the growth of the agricultural sector. Poor road networks, inadequate irrigation systems, and minimal access to modern agricultural technology hindered the sector's ability to expand production and increase yields. This lack of infrastructure restricted the sector's potential for growth and innovation, as well as the opportunity to go on the international market: agricultural export. While there were exports of commodities like coffee, bananas, and sugar, these were often managed by large foreign-owned corporations. The majority of the population remained engaged in subsistence farming, limiting the scope for broader agricultural exports.

3. Limited Value Addition

Value addition through agro-processing and value chain development was underdeveloped. Most agricultural products were sold as raw materials without significant processing or value-added activities. This limited the sector's ability to capture greater value from its products and engage in higher-value markets.

The pre-catching-up agricultural sector in Costa Rica reflected an era of traditional practices, limited modernization, and a focus on subsistence farming. As the nation embarked on its catching-up journey, these challenges and limitations would become opportunities for transformation, leading to a dynamic and diversified agricultural

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landscape that would contribute significantly to Costa Rica's overall growth and development.

Costa Rica's remarkable journey of economic development and growth has positioned it as a standout example of catching-up among nations. We try to investigate the pivotal drivers that have propelled Costa Rica's trajectory of progress, shedding light on the factors that have contributed to its rise as a prominent player on the global stage.

1. Political Stability and Governance

One of the foundational pillars of Costa Rica's catching-up story is its long-standing political stability and effective governance. The nation's commitment to democracy and the rule of law has created an environment conducive to sustained growth. Sound political institutions, relatively transparent governance, and the absence of major conflicts have nurtured a stable atmosphere for investment, both domestic and foreign.

2. Investment in Education and Human Capital

Costa Rica's early investment in education has yielded dividends that continue to shape its catching-up trajectory. The country's emphasis on quality education, literacy programs, and accessible healthcare has led to a highly skilled and educated workforce, which became a critical asset for embracing modern farming practices, technological advancements, and value-added activities.

3. Diversification and Export Orientation

Strategic diversification away from traditional crops and the adoption of export-oriented strategies played a significant role in Costa Rica's agricultural success. The nation shifted from subsistence farming to cultivating high-value export products like coffee, bananas, and ornamental plants, capitalizing on global demand and securing foreign exchange earnings.

4. Technology and Innovation Adoption

The adoption of modern agricultural technologies and innovative practices was instrumental in Costa Rica's catching-up. Investment in research and development, irrigation systems, and mechanization improved productivity, enhanced crop yields, and fostered sustainable farming practices.

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5. Trade and Global Integration

Strategic trade policies and free trade agreements have propelled Costa Rica's integration into the global economy. The nation's ability to harness its competitive advantages and export high-value agricultural goods has not only fueled economic growth but also facilitated the exchange of knowledge and ideas. Furthermore, a favorable business environment and prudent economic policies have made Costa Rica an attractive destination for foreign direct investment (FDI). The country's strategic location, well-developed infrastructure, and skilled workforce have lured international companies seeking a foothold in the Central American market.

Costa Rica's catching-up journey is a testament to the synergy of strategic planning, effective governance, and a commitment to human development and environmental stewardship. The nation's success story underscores the importance of a multi-faceted approach that embraces political stability, education, diversification, innovation, and global engagement. As Costa Rica continues to thrive, its drivers of catching-up serve as a source of inspiration for nations aspiring to forge their own paths toward sustained growth and development.

The initiative for fast development and sustainable growth requires structural transformation. To catch-up with the rest of the world, it is necessary, almost for all developing countries, to consider the most efficient path to converge towards advanced economies. In the context of Costa Rica, the traditional agriculture is not enough to support the need for high-quality growth, not to mention catching-up with developed countries.

Deviating from the conventional agriculture, agricultural tourism, also known as agritourism or agrotourism, can offer several advantages for Costa Rica. This is kind of a very natural choice. First of all, Costa Rica is blessed with rich natural and touristic resources. Costa Rica's lush landscapes and biodiversity make it an attractive destination for tourists. While promoting tourism, what can help the primary sector is to integrate agriculture into tourism offerings, which can enhance the overall appeal of the country, attracting a broader range of visitors. For example, the climate there is suitable for coffee plant. Given the importance of coffee in the urban life, as well as the coffee culture, it would

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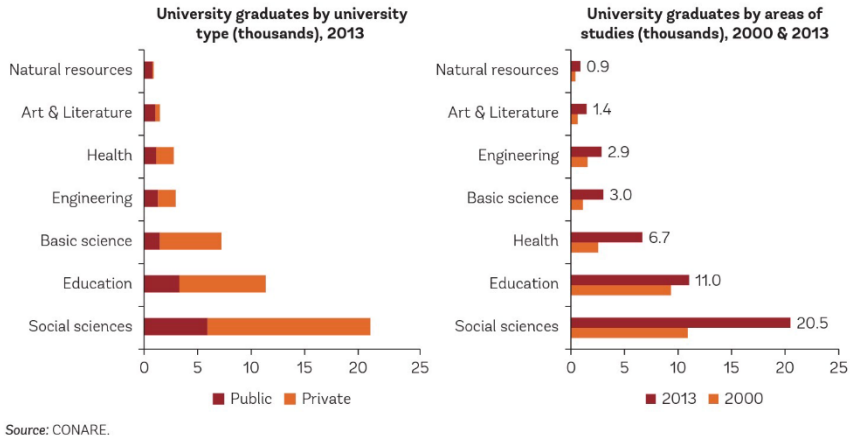
be tempting for provide tourists a chance to get to know how coffee is made from beans. In this way, agricultural tourism allows visitors to connect with local culture and traditions. Tourists gain a deeper understanding of farming practices, food production, and rural life, promoting cultural exchange and appreciation.

Thanks to the previously mentioned policies, particularly about education, local labor market has the human capital stock to support the transition. To attract tourists from all over the world, touristic workers need to be good at English and have the basic service quality. The spread of compulsory education guarantees that visitors can have a good experience.

Figure 17: *The higher education system produces mostly social science graduates*



Source: CONARE.

The benefit is also straightforward. On the extensive margin, developing agricultural tourism can generate employment opportunities in rural areas, reducing urban migration. It can create jobs not only in farming but also in tourism-related services, such as hospitality and transportation. For agricultural works/famers, they earn more. Agritourism activities, such as guided farm tours, farm-to-table dining experiences, or agricultural workshops, often command higher prices than raw agricultural products, yielding much higher profit margins. This can lead to increased revenue for farmers and agricultural businesses. They can also make and sell, maybe even export, value-added products like

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artisanal cheeses, jams, or handicrafts. In the second order, they also have diversified income sources. Relying solely on traditional agriculture can be risky due to factors like weather, market fluctuations, and crop diseases. On the one hand, agricultural tourism can provide an additional source of income, making the economy more resilient, on the other hand, while traditional agriculture may have seasonal income fluctuations, agricultural tourism can generate revenue year-round. Visitors may be interested in different aspects of farming throughout the year.

Lastly, this shift of focus could have a lot of positive externalities. Most important is the preservation of agricultural land. Encouraging tourism on agricultural land can help preserve farmland from urban development. This can be crucial for maintaining the country's food security and protecting its agricultural heritage as well as the forest resources, which is of great significant for the climate change issues. In addition, it promotes sustainable practices. Agricultural tourism often emphasizes sustainable and eco-friendly farming practices. It can serve as a platform to educate tourists about the importance of sustainable agriculture, biodiversity conservation, and responsible land management.

To achieve the transition, Costa Rican government has contributed a lot, particularly on infrastructure construction. From the figure below, Costa Rica has very impressing road density compared to other developing countries in a similar development stage, which is key for tourism and making agriculture enjoy more convenient market access. What's more, internet access is good. Featured by the good index in terms of mobile broadband and 4G coverage, Costa Rica has solid foundation for agricultural tourism to boost agriculture both efficiently and effectively.

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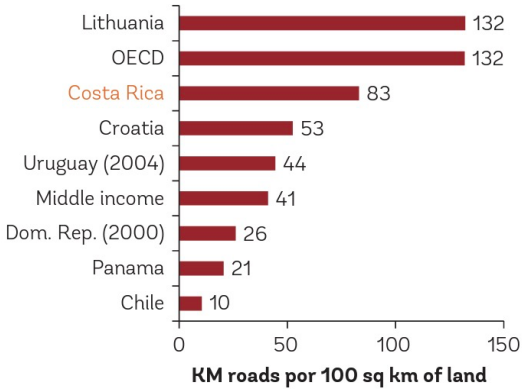
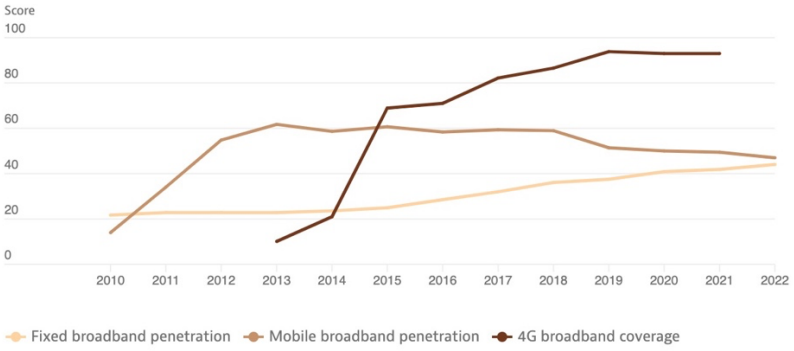
Figure 18: *Road density (2011, unless indicated otherwise)*



Source: *World Bank Group*

Figure 19: *Access*



Conclusion

Costa Rica stands out as a relative success story in Central America in terms of its economic status, characterized by a thriving tourism industry and a dedicated commitment to environmental conservation. The country's path to development has been influenced by robust political institutions, open trade policies, and strategic investments in education, healthcare, and infrastructure. Consequently, Costa Rica has not only achieved significant economic growth but has also diversified its economy, moving away from its traditional dependence on agriculture.

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To gain deeper insights into Costa Rica's economic catch-up journey and its role in the global value chains(GVCs), particularly the role played by the agricultural sector, we use the data available from the World Bank and the UN's FAOSTAT. Specifically, we observe intriguing trends in Costa Rica's agricultural sector when compared to its neighboring countries. Historically, Costa Rica's agricultural output was on par with, or even lagged behind Nicaragua. However, around 1979, Nicaragua witnessed a sharp decline in agricultural production, coinciding with the overthrow of the Somoza government during the Nicaraguan Revolution. Nicaragua only began to recover from this collapse towards the end of the century, allowing Costa Rica to expand its lead in agricultural production, eventually surpassing Nicaragua's agricultural output by approximately two-thirds. These trends are also reflected in their per capita Gross Domestic Product (GDP) data and the social and population crises experienced by Nicaragua. However, it's worth noting that Costa Rica's agricultural sector faced setbacks at two specific points in time. Firstly, during the 2008 financial crisis, the sector's output was severely impacted. Additionally, there was another decline in value in 2018, exacerbated by the impact of the Covid-19 pandemic.

Furthermore, an examination of the Specific Catch-Up Performance Index (SCUPI) within the agricultural sector reveals that while this sector has contributed to economic growth, other sectors have also played a substantial role in reducing income disparities. While Costa Rica's progress is commendable, there remains potential for further acceleration in closing the income gap.

Moreover, our exploration of agricultural tourism as a means of promoting high-quality growth and sustainable development underscores Costa Rica's ability to leverage its natural and touristic resources, create opportunities for future research integration into Costa Rica's agricultural tourism industry.

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4. THE CASE-STUDY OF PHARMACEUTICAL SECTOR IN INDIA

The pharmaceutical sector in India has undergone a remarkable transformation over the years, becoming a global powerhouse of innovation, manufacturing, and export. The origins of India's pharmaceutical industry can be traced back to the pre-independence period when the British introduced Western medicine to the subcontinent.

However, after gaining independence in 1947, the sector witnessed a pivotal shift. The enactment of the Patents Act in 1970, which allowed India to grant process patents for pharmaceuticals and prohibited patenting of end products, marked a turning point. This change paved the way for producing affordable generic drugs and set the stage for the sector's growth (Zacharias and Farias, 2002).

A slew of policy changes after the Patents Act in 1970 made India the largest provider of generic drugs globally. Figure 1 below shows that 1/3rd of the country's exports are to North America, followed by Africa and the EU. The low price and high quality of Indian medicines make them the preferred choice worldwide, rightly making the country the "Pharmacy of the world."

Despite being one of the largest exporters of pharmaceutical drugs, the pharmaceutical sector currently only contributes to around 1.72% of the country's GDP. This low percentage is due to the set of challenges the sector faces in the country. The complex regulatory environment delays the introduction of new drugs and medicines to the market. The regulatory framework is often viewed as cumbersome and time-consuming. Further, India transitioned from a process patent regime to a product patent regime in 2005 to comply with the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS). This change has led to increased scrutiny and legal challenges related to intellectual property rights. Frequent patent disputes and legal battles with multinational pharmaceutical companies have created uncertainty and concerns for the industry.

Despite these challenges, the Indian pharmaceutical sector is a testament to the nation's journey from colonial dependency to self-reliance and global leadership. The industry's resilience, adaptability, and commitment to innovation have solidified India's position on the global pharmaceutical stage. As the sector continues to evolve, it will play a vital role

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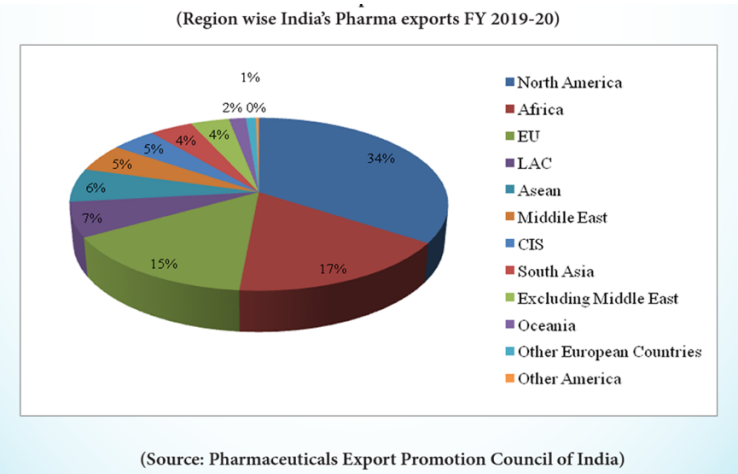
in providing affordable healthcare solutions to people worldwide and shaping the future of pharmaceuticals. With government support, industry dedication, and a spirit of innovation, the Indian pharmaceutical sector is poised for a bright and impactful future.

Figure 20: *India's Pharma Exports*



Theoretical Concepts

Economic catchup is defined in the literature as closing the gap between the country/sector/firm's current state and the benchmarked leading counterpart (Malerba & Lee, 2021; Fagerberg & Godinho, 2005). The vocabulary has a long history going back to Gerschenkron's (1962) book "Economic Backwardness in Historical Perspective" where he described the economic catchup of continental Europe in the late nineteenth century when the United Kingdom was the frontrunner. Abramovitz's (1986) article "Catching-up, forging ahead and falling behind" showed that differences among countries in productivity levels create a strong potential for subsequent convergence of level of productivity, given that the country has enough social capability to absorb the advanced technology. Abramovitz's (1986) hypothesis asserts that being backward in level of productivity carries a potential for rapid growth.

Recent contributions in the stream have proposed that catching up with latecomers does

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not mean cloning the leaders but rather the creation of a divergent course of action compared to the leading country (Malerba & Nelson, 2011; Lee, 2013; Lee & Malerba, 2017). This perspective perceives latecomers as heterogeneous entities that engage in a dynamic learning process within diverse innovation systems (Nelson & Winter, 1982; Dosi et al., 1988; Nelson et al., 2018). Malerba & Lee (2021) define the evolutionary outlook of economic catchup by latecomers, who view catchup as a gradual process of narrowing capability gaps through learning, innovating, and interacting with innovation systems at various levels. The evolutionary process at the country level has been composed of uneven development across industries and sectors since successful catchup does not only need gradual enactment of capabilities but also sometimes leapfrogging and radical jumps which take advance of opportunities in the market or the technological environment (Perez & Soete, 1988; Lee & Malerba, 2017; Malerba & Lee, 2021).

Over the last thirty years, the world economy has experienced a significant transformation due to extensive globalization. The term "global value chains" (GVCs) refers to the interconnected network of production activities that span multiple countries and companies, redefining the international production landscape (Gereffi et al., 2005). GVCs entail intricate and fragmented production networks where countries specialize in specific stages, reflecting the dynamic nature of the modern globalized economy (Humphrey and Schmitz, 2001). These chains highlight the complex interdependence among nations and firms, showcasing how tasks within the value chain are divided based on efficiency and comparative advantages (Kano et al., 2020). Such practices underscore the sophisticated interplay between components and services across various locations, ultimately shaping the contemporary global landscape of trade and production.

Global value chains (GVCs) offer two perspectives; the conventional viewpoint emphasizes potential benefits through heightened integration. This perspective contends that increased participation in GVCs could yield advantages for all involved nations. Such integration could result in trade liberalization, diminished trade barriers, and the liberalization of foreign direct investments (FDI) (Baldwin, 2016; Baldwin & Robert-Nicoud, 2014; Gereffi et al., 2001; Gereffi & Fernandez-Stark, 2011; Frederick, 2014). As outlined

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by Sturgeon et al. (2013) and Baldwin & Robert-Nicoud (2014), developing countries stand to reap substantial benefits from the evolved production structures within GVCs. For developing countries, the GVC ecosystem lends them the opportunity to boost the flow of trade, investments, and knowledge. It acts as a catalyst for rapid learning, innovation, and industrial structure upgrades. Joining GVCs grants them access to advanced technologies and knowledge and also incentivizes them to improve productivity and efficiency.

Contrary to the mainstream belief that more participation in Global Value Chains (GVCs) inherently brings benefits to developing countries, a critical neo-Schumpeterian perspective raises valid concerns. This view challenges the linear notion that increased GVC involvement equates to progress (Lee et al., 2011; Morrison et al.,2008; Pietrobelli & Rabellotti, 2011). Lee et al. (2018) suggest that countries might benefit from early-stage GVC participation, subsequently building domestic value chains and re-entering GVCs after strengthening high-end domestic segments. Lebdioui et al. (2020) further support this by highlighting the successful upgrading of resource-sector GVCs due to long-term industrial policies in Chile and Malaysia.

Scholars like Morrison et al. (2008) criticize the conventional GVC theory for neglecting its ties to innovation and knowledge within developing nations. They argue that complexities in knowledge levels, appropriability, and opportunities for value chain enhancement play crucial roles in this context. Similarly, Lee et al. (2020) contend that GVC participation should be viewed as a stepping stone, not an endpoint. They advocate leveraging local value chains and fostering knowledge creation to unlock higher shares of GVC-generated profits. The absence of building national capabilities while entering GVCs, as these authors suggest, could lead emerging economies into activities of lower added value, potentially resulting in the middle-income trap. The study by Lee (2013) shows that Asian economies, especially China's, move beyond the middle-income trap through the promotion of investment in innovation systems at firm, sectoral, and country levels in what the author calls 'short cycle technologies' and hence creating a new path different from forefront countries. Sustained economic growth through export growth is not guaranteed by opening an economy to international trade or FDI but by building capabilities in local

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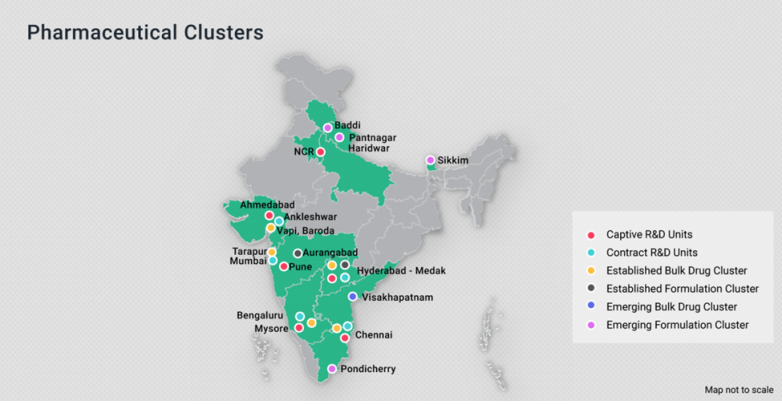
firms and investing in innovation (Jung & Lee, 2010). Analysis of GVC of the coffee industry in emerging countries showed that the challenge for latecomers resides not only in the technological catchup but also in adapting the governance structure alongside dealing with the asymmetry in global value distribution and the tariffs and no-tariffs barriers in the international coffee trade (Lima & Lee, 2023).

Structure, Specialization and Policy Mix

Every economy is a jigsaw of sectors, industries, and policies. How these pieces fit can set a nation's growth trajectory. In India, a blend of agriculture, manufacturing, and services drives the economy. But within this mix, certain industries, shaped by government policies, stand out as growth engines (Malerba & Mani, 2009). India, like many developing nations, aspires to match the advancements of its developed counterparts. This ambition fuels policies that promote industrial growth, spark innovation, and enhance global competitiveness. A prime example here is India's pharmaceutical industry, which showcases how targeted policies can benefit the broader economy (Mani, 2006). The evolving nature of such policies and their global context underscores the government's role in fostering innovation (Mani, 2004).

Figure 21: *Pharmaceutical Hubs in India*



Source: *Formulating success - The Indian pharmaceutical industry by Invest India, 2023*

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India's impressive growth in the pharmaceutical sector has made India a world leader in generic medicines. Several factors fuel this success: a solid scientific base, a skilled workforce, and a commitment to universal healthcare access (Malerba & Mani, 2009). Sudip Chaudhuri's research provides insights into this growth. Chaudhuri (2005) emphasizes India's thoughtful approach to intellectual property within the framework of global regulations, such as those of the WTO. This approach has been pivotal for the industry's expansion. Today, pharmaceuticals don't just contribute significantly to India's GDP (2.9% in 2020-2021) but also address a fifth of the global demand for affordable medicines.

Figure 22: *Pharms Sector's Growth at current prices*

Financial Year	Turnover (Rs. in Crore)	Growth Rate
2017-2018	2,26,423	3.03
2018-2019	2,58,534	14.18
2019-2020	2,89,998	12.17
2020-2021	3,28,054	13.12
2021-2022	3,44,125	4.89

Source: *Pharmatrac/NPPA/DGCIS, Kolkata*

The Indian government's policies have played a crucial role in shaping the pharmaceutical sector's trajectory, a sentiment echoed by Chaudhuri (Chaudhuri, 2005). Intellectual property regulations, for instance, strike a balance between innovation and accessibility. India's focus on generic drugs benefits both domestic competition and its global standing. Policies that champion research and technological collaboration further bolster the industry's innovative spirit.

The narrative of India as the "Pharmacy to the World" captures this policy-industry alignment perfectly (Invest India, 2023). With a portfolio of diverse medicines and exports to over 200 countries, India's pharmaceutical prowess is evident. The commitment to making essential medicines affordable through mechanisms like compulsory licensing further underscores the synergy between policy aims and healthcare goals (The Indian Patents Act, 1970).

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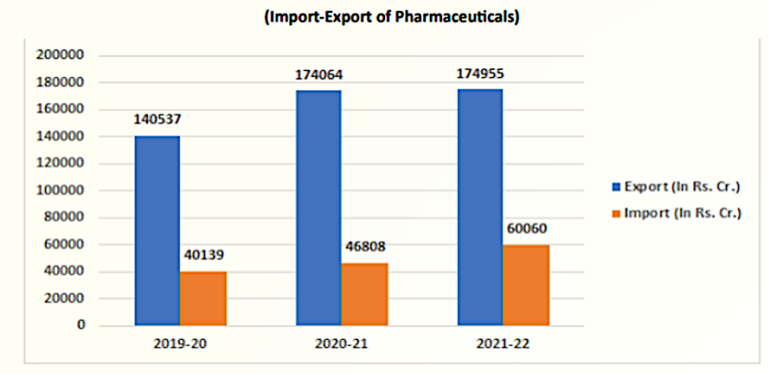
Figure 23: *Pharma Import-Export across three years*



Source: *DGCI&S, Ministry of Commerce and Industry*

The harmony between India's economic fabric, the pharmaceutical sector's specialization, and policy direction is unmistakable. Together, they have transformed India into a hub of both pharmaceutical production and innovative research. Reflecting this commitment, in 2020, India allocated approximately $1.5 billion to pharmaceutical R&D (Ministry of Statistics and Programme Implementation, Government of India, 2021).

Despite its accomplishments, challenges in pioneering drug development remain. For sustained growth, India must boost research investments, refine regulations, and foster collaborations across academia, industry, and research sectors. Balancing local needs with international standards is crucial for the sector's continued ascent. Chaudhuri's work offers a lens to evaluate the future, highlighting the importance of nurturing domestic innovation while ensuring public health (Chaudhuri, 2005).

The way forward demands adept policy crafting that encourages collaborations, prioritizes research, and respects global intellectual property norms. India's economic tapestry, with its vibrant pharmaceutical strand and supporting policies, paints a picture of strategic growth. The nation's quest to "catch up" demonstrates the synergy of industry focus and supportive policies. As India charts its future, insights from Chaudhuri, the pharmaceutical industry's story, and perspectives like those from Invest India will be invaluable.

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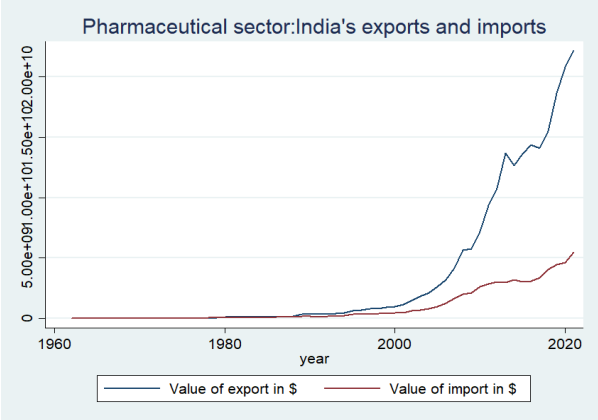
Modelling Approach, Empirical Analysis and Case Study Techniques

In this section, we attempt to understand the extent of catchup in the Indian pharmaceutical sector through a comparative analysis of India's performance trajectory vis-a-vis that of other major global players. From Figure 4 below, we see that over the years, the rate of growth of pharmaceutical exports from India has been greater than that of its imports, especially after the economic reforms in the early 1990s, which facilitated greater integration into the global market. Indian pharmaceutical exports grew at a CAGR of 18.32% in the sixty-year time period between 1962 and 2021, from just over $0.9 million to around $22 billion. During the same period, India's pharmaceutical imports increased by 10.8% year-on-year to touch $5.49 billion in 2021. While undertaking a preliminary comparative analysis of India's performance with respect to other major exporters, we see that India has been steadily catching up in the global pharmaceuticals market (See Table 2). The market concentration has remained fairly the same, with the top exporting country having a 12-15% share. India's export of pharmaceuticals has increased both in terms of value as well as market share in the last 25 years. It is, however, interesting to note that the top exporters of pharmaceuticals remain largely the same over this period.

Figure 24: *India's Trade in Pharmaceuticals: A Historical Perspective*



Source: *Computed using data from the Atlas of Economic Complexity, Harvard University*

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Table 1: *India's Performance in Pharmaceutical Exports vis-a-vis Top Exporters*

Year	Top exporters' share	India's share
1995	Germany (14.6%), UK (11.8%), Switzerland (10.8%)	$529 mn(0.9%)
2000	USA (12.28%), Germany (12.1%), UK (10.9%)	$912 mn (0.96%)
2005	Germany (14.9%), USA (9.35%), France (9.18%)	$2.54 bn(1.03%)
2010	Germany (15.7%), USA (11.1%), Switzerland (10.7%)	$6.99 bn(1.77%)
2015	Germany (14.9%), Switzerland (12.3%), US (11.2%)	$14 bn(2.99%)
2021	Germany (14.3%), Switzerland (11.2%), US (10.1%)	$21.7 bn(2.69%)

Source: *Observatory of Economic Complexity (www.oec.world)*

In order to undertake an objective comparison, we make use of the Catchup Performance Index (CUPI). The CUPI is a relative measure that compares the distance between a country and a reference country or group of countries across two time periods. For our analysis, we examine the distance between the export share of India and the US across the last 25 years, taking 1995 as the base year. The US is taken as the reference country because it is a large country that has had a consistent presence among the top three countries with the highest market share in pharmaceutical exports. CUPI is calculated using the formula below. The numerator is the natural logarithm of the relative difference

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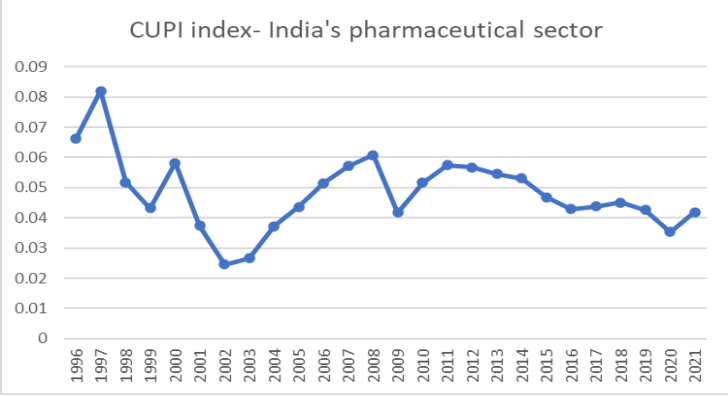
in the export share of the reference country and the country under consideration in the t - th year with respect to the same in the base year. The denominator is the distance between t and the base year. A positive CUPI denotes catching up, while a negative one indicates that the country is falling behind.

The figure below shows the extent of India's catchup with the US in pharmaceutical exports as measured by the CUPI across the last 25 years. CUPI is positive every year, indicating that India is catching up and not falling behind. While the general trend of the rate of catchup was downward till 2002, it rose steadily in the 2003-2008 period, often touted as the golden era of growth in the Indian economy. Subsequently, it has declined and is seen hovering between the 0.04-0.06 range in the past decade.

***Figure 25**: India's Catchup in Pharmaceutical Exports over the Years*



***Source:** Computed using data from the Atlas of Economic Complexity*

Deep Analysis of the Pharmaceutical Sector

The pharmaceutical sector is one significant case where domestic companies have taken over an MNC-dominated sector. Through strategic government policies introduced in the sector over the years and promising roles of domestic firms and laboratories in investments and technology development, the Indian pharmaceutical sector has gained relevance in the world. The situations before and after catching up in the sector are summarised below.

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The country was highly dependent on foreign MNCs for the production of bulk drugs and drug formulations. The market share of MNCs was 68 percent in 1970. With the aim of achieving self-sufficiency in medicinal drugs and reducing the dependence on foreign MNCs, the government of India put many policies in place after the early 1970s. This involved the modernization of the pharma industry, allowing equity participation for foreign MNCs, etc. With these policies, the market share of MNCs in India's pharma sector fell from 68 percent in 1998 to 23 percent in 2004 (Chaudhuri, 2005). The share of MNCs went down further to 18.08 percent by 2016.

Before economic reforms in India, the major share of pharmaceutical drug consumption was supplied by foreign MNCs through imports (Chaudhuri, 2005). In the initial years, the firms imported most of the bulk drugs from their patent companies abroad and sold the formulations at unaffordable prices. To reduce the dependence on imports from MNCs, the government introduced policies like high tariffs and patent laws, which made the Indian market unattractive to the MNCs.

Drivers of catching up

1. Policy initiatives from the 1970s onwards aimed at reducing dependency on MNCs and creating indigenous enterprises:

Drug Policy of 1978, the shift from FERA to FEMA, the Indian Patents Act and its amendment in 2002, TRIPS compliance by 2005, and the new pharmaceutical policy in 2012 all contributed to the growth of the pharmaceutical sector.

2. An intellectual property right regime conducive to incremental innovation:

The prevalence of an intellectual property regime that recognized process innovation facilitated domestic companies to develop alternate, cheaper processes to manufacture existing drugs (Mani, 2023). The TRIPS Agreement created growth opportunities for the Indian pharmaceutical industry, and its participation in GVC has been conducive to the upgradation and transfer of technology. The TRIPS made the industry more R&D-oriented and enabled its movement up the global value chain through a continuous process of change, productivity growth, and innovation.

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3. Focus on science education and the availability of a large pool of chemistry graduates:

The post-independence policy, which focused on higher education in the natural sciences (rather than engineering), created a large pool of chemistry graduates available for employment in the growing pharmaceutical sector (Mani, 2023).

4. State support in the form of R&D incentives that induced innovation:

The role of the state is amply clear in inducing innovation in the pharmaceutical sector. Institutions like the Department of Science and Technology and the Biotechnology Industry Research Assistance Council (BIRAC) have been providing financial assistance and grants for taking up new projects and encouraging research. Mani (2023) finds that since 2005, pharmaceutical firms in India have spent a minimum of 8% of their average sales annually on R&D. Many of the larger companies have also created standalone R&D centers and engaged in technology collaborations with peers. Besides these, diverse funding through budgetary support, venture capital, CSR funds, etc., motivates startups and pharmaceutical companies in their research endeavors (Saraf, 2023).

5. Internationally renowned research laboratories and institutes to drive innovation:

Public sector firms like Hindustan Antibiotics Ltd. (HAL) and Indian Drugs and Pharmaceuticals Ltd. (IDPL) played a major role in technical competence building in the sector. These firms created a high demand for skilled laborers and encouraged engagements with academia. Efforts were also made for the exchange of technologies between the two firms. Moreover, the technologies available in these two firms spilled over to the private sector. The public sector research laboratories under the Council for Scientific and Industrial Research (CSIR), like the Central Drug Research Institute (CDRI), Indian Institute of Chemical Technology (IICT), and National Chemical Laboratory (NCL), also contributed considerably to the growth of the Indian pharmaceutical industry. The laboratory-level processes developed in these laboratories were transferred to the private sector, which later scaled up to the industry level. Almost all Indian pharmaceutical companies have used the service of these CSIR laboratories. They were phenomenal in developing process technologies for vitamin B6, azithromycin, ciprofloxacin, etc. Through the movement of R&D personnel, these technologies were spilled over to the private

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sector, too (Smith, 2000; Parthasarathy, 2007; Chaudhuri, 2005).

6. The emergence of thriving domestic companies to provide technological and thought leadership to younger firms:

As a response to the delicensing and liberalization of the limits on foreign equity participation, the 1980s saw the emergence of domestic companies such as Ranbaxy, which became major players in the sector. The success of these pioneer firms further inspired indigenous entrepreneurship in the pharma sector, eventually leading to a situation where the market share of MNCs declined from 68% in 1970 to a mere 23% in 2004 (Chaudhuri, 2005).

7. High investment in the sector:

Next figure shows the pattern of investment in the pharma sector. A clear shift in the gross fixed capital formation can be seen since 2003-04. Combined with the government policies explained above, TRIPS also contributed to the high investment in the sector. As a result, the number of factories, according to the Annual Survey of Industries (ASI), has increased from 1794 in 1990-91 to 5326 in 2019-20.

8. Strategic Policy Interventions and Growth of Small Firms:

The sector has accommodated a large number of small units. They have significantly contributed to the production as well as employment generation. The reasons for the growth of small firms include the strategic policy interventions by the government that covered a soft patent regime, relaxation in industrial licensing and pricing policy, etc (Pradhan, 2011).

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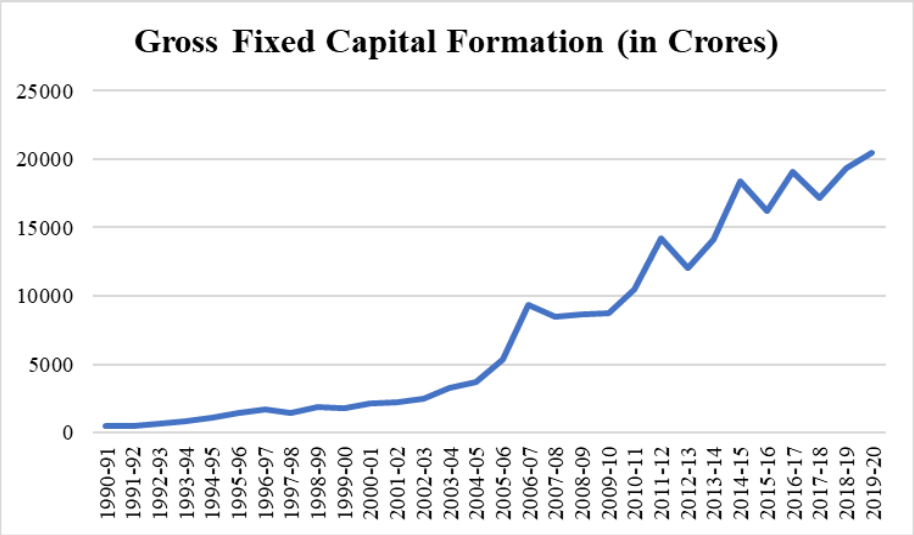
Figure 26: *Gross Fixed Capital Formation in the Indian Pharmaceutical Sector*



Source: *Annual Survey of Industries, Govt of India*

Conclusion

The transformation of the Indian pharmaceutical sector in the last 50 years from an MNC-dominated, import-dependent one to an export-oriented indigenous sector has been remarkable. Even a cursory glance at the export trajectory of the Indian pharma sector would tell us that the sector is thriving with increased participation in the global value chain. To gain deeper insights into the Indian pharmaceutical industry's catchup journey, we use the data from the Atlas of Economic Complexity, Harvard University, and examine the degree of India's catchup in the 1995-2021 time period, taking the US as a reference country. The positive sign of CUPI in each of the years indicates that India's pharma sector isn't a laggard when it comes to participation in the global value chain. The state, along with the market, has played a major role in this journey through strategic policy initiatives and enhanced technology development in the sector driven by the domestic firms in the sector. While the country has emerged as a leader in generic medicines and contract manufacturing through process innovation and effective utilization of the labor arbitrage

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that exists in India, the next frontier to break would be in the development of new formulations and vaccines through cutting-edge, disruptive innovation.

5. THE CASE-STUDY OF TELECOMMUNICATION SECTOR IN SOUTH KOREA

Korea's telecommunication sector stands as a beacon of technological advancement and innovation on the global stage. The Korean telecoms industry was one of the first to pave the way for the 2nd generation era with QUALCOMM's CDMA technology. Subsequently, in the 2000s, the adoption of Wideband Code Division Multiplex Access (WCDMA) technology propelled the industry into the 3rd-generation, enabling faster communication speeds and the introduction of services like video calls and wireless internet. SK Telecom's launch of the ALL-IP-based LTE network marked the advent of the 4th generation, boasting data speeds substantially higher than its predecessor, ushering in services supporting high-quality videos and 3D content (Yang et al., 2016).

Korea's telecom industry, renowned for its global standards and competitiveness in the 4th-generation, witnessed a rapid evolution. As the 4th-generation facilitated wireless data and broadcasting integration, it paved the way for diverse services like integrated multimedia content, e-commerce, and other innovative offerings. This sector emerged as a cornerstone in shaping the knowledge-driven 21st-century society, exerting far-reaching impacts on the national economy and cultural landscape through consumption patterns, production methods, and employment opportunities. This growth is reflected in the number of software specialists in the country grew at an annual average of 7.7% to 352,000 in 2021 (Ministry of Science and ICT's Software Export Survey, 2022).

Transitioning to the 5th-generation in 2019, Korea's telecom industry set new benchmarks worldwide with ultra-high-speed, large-volume transmission capabilities, ultra-low latency, and unprecedented connectivity through Gigabit per second (Gbps) speeds and high band frequencies (Kwon & Kim, 2021). Structurally, the number of 5G subscribers has increased significantly to 29.6 million, contributing to a remarkable 136.8% increase in 2020. In addition, the subscription rate for OTT services expand to 69.5%, reflecting the rapid pace

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of digitalization (ITSTAT, 2022).

The ICT industry's share of total output reached KRW 560 trillion, with a closer look at the industry showing that ICT devices accounted for 70.3% of the industry's total output, ICT services 15.8% and software 13.9%. The telecoms industry is seen as a growth catalyst for the national economy and is expected to expand into various sectors to drive technological advancement and industrial convergence. From downstream sectors such as self-driving vehicles, transportation, logistics and healthcare to upstream manufacturing industries such as semiconductors, displays and modules, the impact of the advanced telecommunications industry is expected to be very large (Lee et al., 2019).

Theoretical Concepts

The concept of "catching up" has become commonplace in development economics literature when it comes to developing or emerging countries reducing their development gap compared to more advanced nations. The concept is often associated with the term "convergence", which goes beyond the economic catching-up process (Amable, 1993). It involves a holistic strategy that encompasses various aspects including technological, industrial, social development and institutional reforms to expedite growth and achieve parity with more developed nations. However, technological progress is a cornerstone of the emerging economies' catch-up strategies (Lin, 2017). Emerging economies endeavour to bridge the technological gap by acquiring, adapting, or innovating new technologies. This involves technological diffusion, investment in research and development, and fostering an environment conducive to innovation and knowledge transfer.

Furthermore, the catching-up process usually requires a transition from the traditional or agricultural sector to industrialization (Wong & Cheong, 2014). This shift entails upgrading production capabilities, enhancing productivity, and diversifying the industrial base. Through industrial policies and investments, countries aim to build competitive industries and create employment opportunities. Investing in education, training, and skill development is vital for catching-up. Recognizing the central role of education, training and skills development, investment in these areas is essential for a successful catch-up

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process (Nübler, 2014). A skilled labour force that is able to quickly adapt to new technologies and drive innovation is a critical factor in reducing the development gap.

These catch-up efforts are facilitated by effective governance structures, supportive institutions and a favorable policy environment (Lee, 2013; Nelson, 2004). Implementing various economic policies, promoting infrastructure development, opening up trade and creating a stable regulatory framework are essential components that attract investment and promote sustainable growth. These collective elements play a crucial role in driving the economic and technological catch-up of nations.

The concept of global value chains (GVCs) refers to the entire sequence of interconnected activities involved in the production and supply of goods and services on a global scale. It encompasses the various stages of production from design and raw material extraction to manufacturing, assembly, marketing and distribution across different companies, regions and sometimes continents (Gereffi et al., 2005). For example, raw materials may be sourced from one country, assembled in another and sold in yet another market. Companies often spread their production processes across different countries to take advantage of the cost efficiencies, specialized skills and resources available in different regions (Humphrey & Schmitz, 2001). This international division of labour enables the creation of complex supply chains that lead to specific value-added components of the final product.

GVCs facilitate the cross-border transfer of technology, knowledge and management practices, which particularly benefits emerging economies that want to expand their industrial capabilities (Williamson, 2015). By participating in GVCs, these economies gain access to advanced technologies and specialized knowledge inherent in the complicated production processes of multinational corporations (MNCs) or leading companies (Cuervo-Cazurra & Pananond, 2023). This access fosters a favorable environment for technological learning and the adoption of best practices as emerging economies engage at different stages of the value chain. Whether through joint ventures, supplier relationships or subcontracting agreements, these interactions enable the transfer of cutting-edge technologies, innovative methodologies and sophisticated management

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techniques. Consequently, this engagement helps to improve the technological capacity and skills of local industries and labour in emerging economies, facilitating their development towards higher value-added activities and increasing their competitiveness on the global stage (Kummritz et al., 2017).

Global value chains (GVCs) play a central role in promoting economic development and facilitating the catching-up process of many developing countries worldwide. Through their participation in GVCs, these countries have experienced a transformation of their economies that has led to advances in industrialization, technological capabilities and overall growth.

GVCs have supported the catching-up process primarily by providing developing countries with access to advanced technologies and knowledge (De Marchi et al., 2018). Through integration into global production networks, these countries have been able to acquire and adapt technologies that were previously beyond their reach (Pietrobelli & Rabellotti, 2011). Multinational corporations, often acting as leaders within GVCs, have facilitated technology transfer, enabling local companies in developing countries to learn and implement more efficient production methods. This access to advanced technology has acted as a catalyst for innovation and industrial modernization, enabling these countries to increase their productivity and competitiveness.

In addition, participation in GVCs has contributed significantly to industrial development in developing countries (Kowalski et al., 2015). By being integrated into international production chains, these countries have been able to use their comparative advantages, such as low-cost labour or access to certain resources, to attract foreign investment and establish production sites. This has led to job creation and the development of industrial clusters in various sectors (Tian et al., 2022). As a result, many developing countries have diversified their economies, shifting from primary sectors to manufacturing and higher value-added service-orientated activities.

GVCs have also promoted skills development and improved human capital in developing countries (Tajoli & Felice, 2018). As these countries are involved in different stages of the value chain, the demand for skilled labour capable of handling advanced technologies and

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specialized tasks is increasing. This has led to investment in education, vocational training programme and skills development initiatives, which has contributed to an increase in overall human capital in these countries. A better educated labour force has not only improved productivity, but has also enabled local industries to take on more complex tasks within the global production network.

In addition, participation in GVCs has expanded market opportunities for developing countries. Integration into GVCs gives these countries access to larger and more diverse markets (Bamber et al., 2014). This integration enables them to export their products and services to a broader consumer base, increase trade volumes and generate economic growth. In addition, participation in GVCs provides the opportunity to familiarize themselves with global best practices, quality standards and marketing strategies, enabling developing countries to improve the competitiveness of their products in international markets (Ponte & Gibbon, 2005).

Participation in global value chains has significantly helped developing countries in their efforts to catch up by serving as a channel for technology transfer, industrial growth, skills acquisition and market adaptation. Despite the tremendous opportunities it presents, robust policies and strategies need to be implemented to overcome the associated hurdles. It is imperative to ensure that engagement in GVCs promotes inclusive and sustainable development in these countries.

Structure, Specialization and Policy Mix

The Korean telecommunications sector is primarily characterized by three large companies that dominate the market: SK Telecom (SKT), KT Corporation (formerly Korea Telecom) and LG Uplus. These three companies are the main players in the provision of a wide range of telecoms services, including mobile telephony, broadband Internet and IPTV (Internet Protocol Television) (Massaro & Kim, 2022). SK Telecom, a leading company in the industry, has a significant market share in mobile services and has been actively involved in the development of technologies such as 5G networks, artificial intelligence (AI) and the Internet of Things (IoT) (Kim, 2016). KT Corporation, another

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major player, is focusing on the expansion of broadband Internet services and IPTV offerings while investing in the development of 5G infrastructure. LG Uplus, which belongs to LG Corporation, competes fiercely in the mobile, broadband and IPTV markets and is focusing on technological innovation and advances to maintain its competitiveness (Choe et al., 2023; Massaro & Kim, 2022). This triopoly structure, combined with a strong emphasis on technological innovation and infrastructure development, has contributed significantly to South Korea's reputation as a global leader in the telecoms industry (Sánchez & Carro, 2017).

South Korea has shown remarkable industrial specialization, particularly in the telecommunications sector. This phenomenon has made the country a global technological powerhouse, setting standards for innovation, infrastructure development and commercial deployment (Choe et al., 2023; Lee et al., 2023). The deliberate focus on specialization within the telecommunications industry has not only contributed significantly to South Korea's economic growth, but has also made the country a leading force in the global technology landscape (Sawng et al., 2021).

The foundation for South Korea's industrialized specialization in the telecommunications sector lies in the government's strategic planning and initiatives (Lee, 2020). The government played a crucial role by formulating policies and regulatory frameworks that encouraged competition, innovation and infrastructure development (Lee et al., 2023). Initiatives were taken to incentivize research and development, encourage private investment and facilitate collaboration between industry players (Falch & Henten, 2010; Jin, 2006).

An important aspect of South Korea's specialization in the telecommunications sector is its unprecedented infrastructure development. The country has an extensive and highly developed broadband network, including high-speed internet connections that are accessible to the majority of the population (Choudrie & Lee, 2004). Investments in fiber optic networks and advanced wireless technologies has made South Korea a global leader in connectivity, providing fast and reliable internet services nationwide (Lee & Chan-Olmsted, 2004).

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The emergence of technology giants such as Samsung Electronics and LG Electronics has contributed significantly to South Korea's industrial specialization in the telecommunications sector. These companies have invested heavily in research and development, driving innovation in various areas of telecoms, from hardware manufacturing to software development (Park & Lee, 2006). Samsung Electronics in particular has made a significant contribution to the development of mobile phone technology. The company's smartphones have repeatedly pushed boundaries, introduced innovative features and set industry standards. In addition, the company's involvement in the development of 5G technology has further cemented South Korea's position as a leader in the field of telecommunications (Gillispie, 2020).

South Korea's specialization in the telecommunications sector is particularly evident in its leadership in 5G technology. The country was one of the first to commercially launch 5G networks, which offer unprecedented speed and connectivity (Gillispie, 2020; Hong et al., 2021). This technological leap has not only enabled faster internet access, but has also opened the doors for innovative applications in various sectors, including healthcare, autonomous vehicles and smart cities.

The industrialized specialization of South Korea's telecommunications sector has had a profound impact globally. The country's expertise and technological advancements have led to collaborations and partnerships with international companies and boosted economic growth through the export of telecommunications equipment and services (Choe et al., 2023; Massaro & Kim, 2022). In addition, South Korea's specialization in the telecommunications sector has enhanced the country's global reputation as a technology hub, attracting foreign investment and talent and fostering an ecosystem that encourages start-ups and technological innovation (Lee & Lee, 2021).

South Korea's industrial specialization in the telecommunications sector is a testament to its visionary planning, technological innovation and strategic collaboration (Lee, 2020). The country's relentless pursuit of excellence has made it a global leader in telecommunications, fueling economic growth and shaping the future of connectivity and communications on a global scale. As technology continues to advance, South Korea's

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expertise in the sector remains critical to the development of the global telecoms landscape.

The South Korean government has taken a series of comprehensive policy measures to revitalize the telecommunications industry, promote competition and at the same time prevent monopolistic tendencies (Chu, 2021; Kim et al., 2010). These initiatives, driven by regulatory frameworks and market-oriented strategies, have fueled the growth of prominent players such as SK Telecom, KT Corporation and LG Uplus. Through strict antitrust regulations, licensing criteria and spectrum allocation guidelines, South Korea has prioritized fair competition, encouraged innovation and provided consumers with a wider range of choices (Lee, 2020). These measures have not only encouraged innovation, but have also helped to create a dynamic and competitive telecoms market in the country.

Furthermore, South Korea's relentless commitment to research and development (R&D) has been instrumental in positioning the country as a global leader in telecommunications technology. By fostering innovation in burgeoning areas such as artificial intelligence (AI), the Internet of Things (IoT) and smart devices, the government has been instrumental in driving technological advancement in South Korea (Gillispie, 2020). Policies that support collaboration between industry, academia and government, as well as financial support through grants and subsidies, have enabled groundbreaking advances in these innovative fields (Lee, 2020). These concerted efforts have not only driven technological progress domestically, but have also cemented South Korea's reputation as a hub for cutting-edge telecommunications technologies on the global stage.

In parallel, South Korea's commitment to digital inclusion and accessibility has played a crucial role in ensuring broad access to telecoms services across the country. The government recognizes the importance of equal access, particularly in remote and underserved regions, and has prioritized initiatives to narrow the digital divide (Frieden, 2005). Strategies focusing on universal access to high-speed internet and mobile communication services include infrastructure development in remote areas, subsidies for low-income households and educational programme to promote digital literacy (Forge &

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Bohlin, 2008; Frieden, 2005). These collective efforts underscore the government's unwavering commitment to providing equal opportunities for all people in South Korea to actively participate in and benefit from the digital age, promoting a more inclusive society. Furthermore, South Korea's introduction of a robust consumer protection policy in the telecoms sector underlines its commitment to fair practices and transparency. With regulations that ensure clear terms of service, fair pricing and effective dispute resolution mechanisms, the government is protecting the rights of consumers (Falch & Henten, 2010). Strict enforcement of privacy regulations strengthens the security of personal data, while transparent billing practices and accessible complaint channels increase consumer confidence (Shin, 2017). Through these measures, the South Korean government is actively promoting a credible and reliable environment for consumers by encouraging fair competition and boosting consumer confidence in the telecoms sector. These combined efforts reflect South Korea's commitment to a thriving, competitive and consumer-centered telecommunications industry.

Date Source, Indicators and Empirical Methodology

Preceding an exhaustive analysis of the catch-up performance dynamics within South Korea's telecommunication sector, this study commences by laying the groundwork with a macro-level picture about its overarching economic development pathway. GDP per capita measured in purchasing power parity (PPP) dollars at constant prices in 2015 is employed to look into the economic catch-up performance of Korea from 1980 to 2022.

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Table 2: *Indicators, Measurement and Data Source*

Indicators	Measurement	Data Source
Economic development	GDP per capita (PPP constant 2015 US$)	World bank, World Development Indicators database
Market share	ICT goods exports (% of total goods exports)	World bank, World Development Indicators database
R&D Investment	Gross domestic spending on R&D	OECD, Innovation and Technology database
Talents	Researchers	OECD, Innovation and Technology database
ICT infrastructure development	Fixed broadband subscriptions (per 100 people)	World bank, World Development Indicators database
Competitiveness	ICT Paten number	OECD Patent Statistics

Note: ICT paten number refers to applicant(s)'s country(ies) of residence and priority date in the dataset.

Furthermore, the study will intricately explore South Korea's catch-up progress by using the United States as the benchmark country in the telecommunication sector across five critical dimensions, namely market share, investments in research and development, talents, ICT infrastructure development, and competitiveness (Table 4.1). Specifically, the study specifically employs the proportion of Information and Communication Technology (ICT) goods exports concerning total goods exports as a pivotal indicator for evaluating market share within South Korea's telecommunication sector. Normally, a growing percentage of ICT goods exports to total goods exports means a more and more important contribution of ICT sector for a country. Moreover, it also manifests the increasingly competitive discourse power in the global market in terms of technology progress, cost competitiveness and innovative product portfolios (Lee et al., 2023).

R&D Investment, talents and ICT Paten number reveal the three primary drivers, i.e., financial supports, human capital and technological progress that sustains telecommunication sector development in the long term. In the study, gross domestic spending on R&D, number of researchers and ICT Paten number are feasible measurement, respectively. On one hand, R&D investment and ICT patent number

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indicate the level of innovation and technological advancement in telecommunication sector, contributing to producing new technologies, products, and service (Hong, 2017; Im & Lee, 2021). Also, excellent professional researchers could greatly boost novel knowledge creation and emerging technology implication either in theoretical and practical aspects (Chung & Lee, 2015). In this sense, companies or counties obtain a stronger competitive edge in the telecommunication sector.

Fixed broadband subscriptions per 100 people serve as a feasible indicator to measure telecommunication industry development in a nation as it reflects the penetration and accessibility of fixed broadband internet services within a country. In addition, it shows the digital infrastructure state of a nation in certain period. A robust and extensive telecommunication infrastructure is essential for various economic activities, education, healthcare, and societal development (Sawng et al., 2021). In essence, this indicator gauges the digital connectivity, technological advancement, economic potential, and societal impact from the telecommunication sector in a country.

To better capture the dynamics of catch-up performance for one country towards to the frontier country, the Catch-Up Performance Index (CUPI) is widely used in related researches. It is a feasible tool to evaluate a nation's advancement in bridging the gap with more developed economies, specifically in terms of income or economic growth. Normally, the United States is utilized as the benchmark or frontier country. Referring to Kant (2019), Vu and Nguyen (2022) and Vu et al. (2019), the CUPI is defined as follows in the study:

$$CUPI_{0,T}^{i} = ln\left[\frac{rel\_y_{T}^{i}}{rel\_y_{0}^{i}}\right]/T$$

where $CUPI_{0,T}^{i}$ is the catch-up performance index of country i over the period [0, T]; $rel\_y_{T}^{i}$ is GDP per capita measured in purchasing power parity (PPP) dollars at constant prices of country i relative to the United States:

$$rel\_y_{T}^{i} = \frac{y_{t}^{i}}{y_{t}^{US}}$$

where y_{t}^{i} and y_{t}^{US} are the GDP per capita measured in purchasing power parity (PPP)

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dollars at constant prices of country i and the United States in year t. While $rel\_y_0^i$ is the same difference but at the base year.

By definition, $CUPI_{0,T}^i > 0$ if country is catching up ($rel\_y_T^i > rel\_y_0^i$), $CUPI_{0,T}^i < 0$ if it is falling behind ($rel\_y_T^i < rel\_y_0^i$), and $CUPI_{0,T}^i = 0$ if it is neither catching up nor falling behind ($rel\_y_T^i = rel\_y_0^i$). Therefore, the sign and magnitude of the CUPI index offer a significant measure for evaluating a specific country's catch-up performance concerning GDP per capita throughout the analyzed period.

Similarly, to capture the specific sector's dynamics in a country, Sector Catch-Up Performance Index (SCUPI) is introduced as follows:

$$SCUPI_{0,T}^i = ln\left[\frac{rel\_y_T^i}{rel\_y_0^i}\right]/T$$

where $SCUPI_{0,T}^i$ is the catch-up performance index of certain sector in specific dimension such as R&D investment, talents and patens and so on over the period [0, T]; $rel\_y_T^i$ is the relative difference of the certain indicator in a certain sector in a country to the United States:

$$rel\_y_T^i = \frac{y_t^i}{y_t^{US}}$$

where y_t^i and y_t^{US} are the certain indicator in a certain sector in country i and the United States in year t. While $rel\_y_0^i$ is the same difference but at the base year.

Similarly, $SCUPI_{0,T}^i > 0$ if the sector is catching up in terms of the specific aspect ($rel\_y_T^i > rel\_y_0^i$), $SCUPI_{0,T}^i < 0$ if it is falling behind ($rel\_y_T^i < rel\_y_0^i$), and $SCUPI_{0,T}^i = 0$ if it is neither catching up nor falling behind ($rel\_y_T^i = rel\_y_0^i$). Thus, the sign and magnitude of the SCUPI index provide a significant measure to assess the catch-up performance of a particular sector concerning specific aspects over the analyzed period.

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Economic Catch-up Performance of Korea

Figure 27 delineates Korea's economic catch-up trajectory from 1980 to 2022. The Cumulative Catch-Up Performance Index (CUPI) consistently maintained positivity, signifying Korea's sustained endeavors aimed at bridging the gap with the US concerning GDP per capita during the study's duration. However, the CUPI exhibited a consistent yet declining trend from 1981 to 2022, denoting a waning pace in Korea's GDP per capita convergence with the US over time.

Initially, the CUPI demonstrated elevated values (approximately 0.025 to 0.030) in the early 1980s, indicative of a comparatively brisk rate of convergence. From the mid-1980s to the early 2000s, the CUPI remained relatively stable (around 0.020 to 0.030), signaling a persistent trajectory in narrowing the gap. Subsequently, post-2000s, the CUPI depicted a gradual descent, highlighting a diminished pace of convergence, with values gradually descending below 0.020. Nevertheless, despite this deceleration, the CUPI persistently retained positivity, symbolizing sustained initiatives to mitigate the GDP per capita differential with the US.

In summary, the affirmative trajectory of the CUPI underlines Korea's unwavering commitment and strides in economic development in comparison to the US. However, the declining trend in CUPI intimates a deceleration in Korea's GDP per capita convergence with the US, potentially suggestive of impediments or reaching a saturation point in economic growth.

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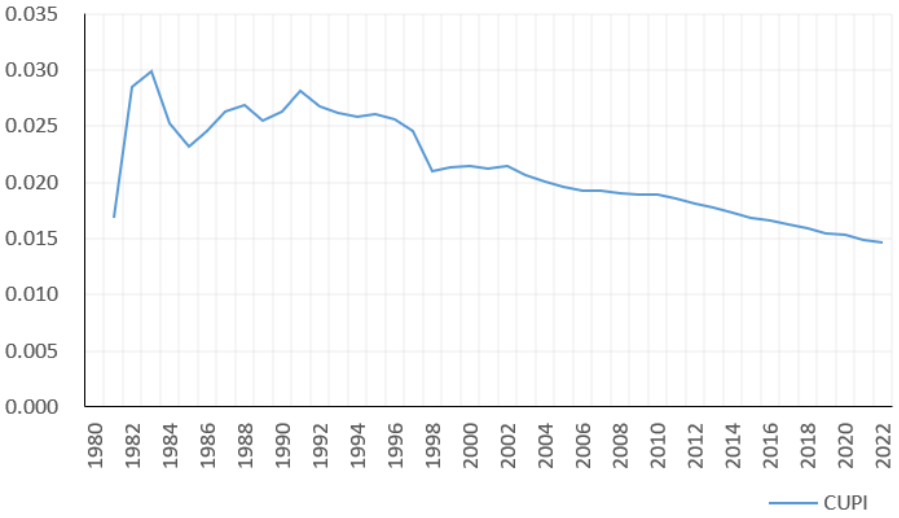
Figure 27: *Economic Catch-up Performance of Korea: 1980 to 2022*



Note: *GDP per capita (PPP constant 2015 US$) is used to calculate the CUPI, US is the benchmark.*

Source: *World Bank, World Development Indicators database (2023)*

Analysis of the Telecommunication Sector In Korea

South Korea stands among the countries with the most extensive adoption rates of communication technology, boasting highly advanced fixed and mobile communication networks. As of 2022, out of South Korea's 20.85 million households, a remarkable 20.64 million actively engaged with the internet, demonstrating an exceptional internet adoption rate of 99.96% (Figure 28). Among the population of 50.81 million individuals aged three or older, the count of internet users totaled 47.25 million, accounting for 93% of the nation's populace.

The telecommunication sector in Korea has been characterized by intense competition and a culture of innovation. Major telecom service providers such as Samsung, LG, SK Telecom, and KT have consistently maintained leading positions in communication technology, network infrastructure, and service innovations (Choe et al., 2023). Korea has established a sophisticated communication infrastructure, including high-speed

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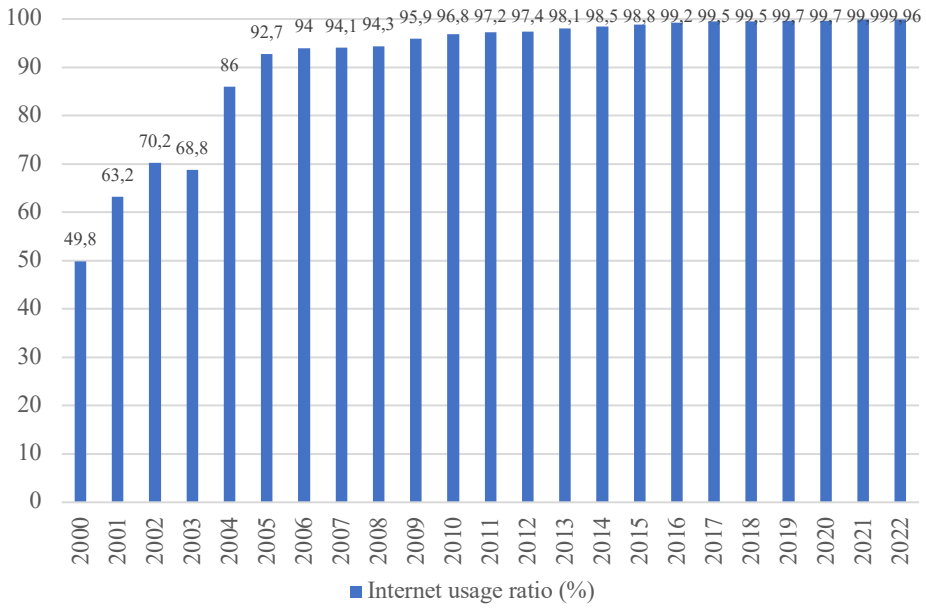
broadband Internet and widespread 4G/5G networks, offering users fast and dependable communication services (Massaro & Kim, 2022).

Furthermore, the Korean telecommunication industry has remained at the forefront of technological advancements and service innovations. Notably, Korea has made significant strides not only in hardware technology but also in the innovation of communication services, applications, and content (Choe et al., 2023). The telecommunication landscape in Korea is notably competitive, fostering a continuous drive among telecommunication companies to explore potential growth opportunities and enhance services to sustain their competitive advantage.

Figure 28: *Internet usage rate in Korea*



Data source: *2022 Korea Internet White Paper*

Drivers of Catching-Up Performance in the Korean Telecommunication Sector

In the pursuit of catching up with other countries or sectors, the Korean telecommunication sector is propelled by several driving forces. Primarily, technological innovation plays a pivotal role. As suggested by the neoclassical growth theory, technology operates as an

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endogenous variable and has the potential to notably augment output (Mokyr, 2018). Korean companies consistently allocate their profits toward the development of new technologies like 5G, artificial intelligence (AI), and the Internet of Things (IoT) (Massaro & Kim, 2022). These advancements not only enhance network performance and widen service domains but also lead to cost reductions.

Secondly, international competitiveness plays a significant role. Through active participation in the global market, Korean companies discern their competitive advantages and disadvantages by engaging in both competition and collaboration with other international entities (Lee et al., 2023; Lee & Lim, 2001). This engagement has facilitated the Korean telecommunication sector in becoming a frontrunner on the global stage. Concurrently, Korean telecommunication companies consistently allocate substantial resources toward research and development (R&D) for the advancement and application of new technologies, striving to uphold their global competitiveness (Hong, 2017). Furthermore, the Korean telecommunication sector has fostered close industrial alliances with partners in various sectors, thereby enhancing overall competitiveness within the global value chain through collaborative efforts, innovative practices, and shared resources (Lee et al., 2021; Lee et al., 2016).

Thirdly, the development of digital infrastructure plays a pivotal role. Continuous advancements and enhancements in digital infrastructure serve as the foundation for innovation and advancement within the telecommunication sector (Sawng et al., 2021). Leveraging this progressive digital infrastructure, Korea facilitates enhanced coverage and improved service quality for broadband and mobile networks, culminating in an enriched user experience and increased utilization of diverse communication services (Hong, 2017). Furthermore, the development of digital infrastructure aids in extending the reach of communication networks, particularly in remote regions of Korea (Frieden, 2005). This extension contributes significantly to promoting digital inclusivity and fostering equitable social development (Frieden, 2005).

Fourthly, the market environment plays a pivotal role in the telecommunication sector's development, delineating the competitive standing of individual company within the market

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landscape. Operating within a competitive market necessitates telecommunication companies to continually enhance service quality, reduce pricing, and introduce innovative products and services to expand their market share (Saba & David, 2023). In pursuit of market dominance, telecommunication companies tend to escalate their investments in infrastructure, including network enhancements and the integration of new technologies (Choe et al., 2023). This concerted effort drives the overall advancement of the telecommunication infrastructure in Korea. Consequently, the competition for market share acts as a catalyst, propelling the sector forward in terms of service quality, technological innovation, and operational efficiency (Nakatani, 2021).

Catch-Up Dynamics of the Koren Telecommunication Sector

Based on the Sector Catch-Up Performance Index (SCUPI), this section deeply investigates the catch-up dynamics of from five dimensions, namely general market share, R&D Investment, talents, ICT infrastructure development and competitiveness.

Figure 29 shows the catch-up performance of Korea's ICT market share referring to U.S. Initially, spanning from 2001 to 2005, the SCUPI indicated a downward trend, signifying a decrease in Korea's market share concerning the USA. This trend persisted with consistently negative SCUPI values recorded between 2006 and 2015, indicating a continuous albeit less pronounced decline in Korea's market share relative to the USA. However, a shift emerged from 2016 onwards, denoted by a slight improvement in SCUPI, resulting in a shift to positive values. The subsequent positive SCUPI observed from 2017 to 2021 suggests a gradual improvement in Korea's market share, implying a slow yet steady recovery and an augmented position in this specific sector in comparison to the USA.

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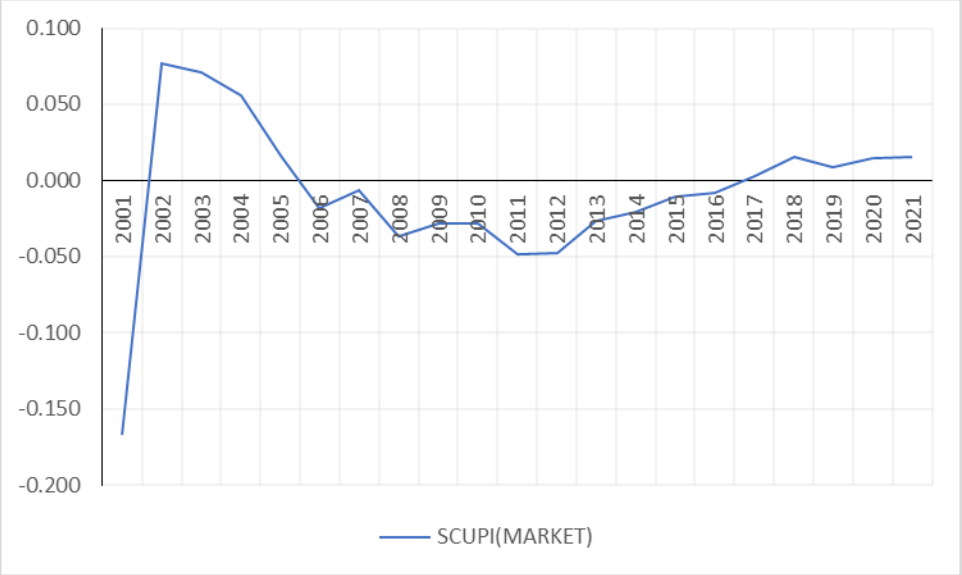
Figure 29: *ICT Market Share Catch-up Performance of Korea*



Source: *World bank, World Development Indicators database*

Figure 30 presented the R&D investment catch-up dynamics between Korea and the USA from 1999 to 2022. From 1999 to 2006, Korea exhibited a positive SCUPI, indicating its higher gross domestic spending on research and development in comparison to the USA. However, there was a subsequent declining trend during this period, revealing a reduction in Korea's advantage in R&D investment compared to the USA. This downward trajectory persisted from 2007 onwards, reflecting a sustained decrease in Korea's lead in R&D investment relative to the USA. Despite this, the SCUPI consistently remained positive, signifying Korea's ongoing but gradually diminishing edge in R&D spending, a trend that persisted until 2022. This sustained decline, although still positive, demonstrates a narrowing gap and a diminishing R&D investment advantage that Korea previously held over the USA.

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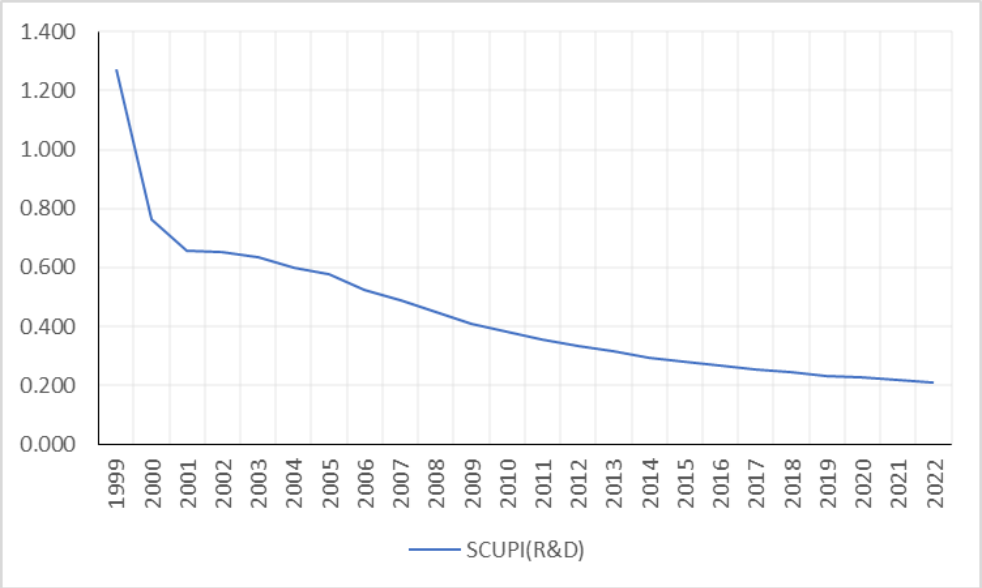
Figure 30: *R&D Investment Catch-up Performance of Korea*



Source: *OECD, Innovation and Technology database*

Figure 31 illustrated the talent catch-up performance between Korea and the United States. Between 1992 and 2006, Korea's SCUPI consistently presented negative values, reflecting a significant talent gap compared to the United States. However, a notable shift emerged from 2007 onwards, as the SCUPI exhibited fluctuations around zero and gradually turned positive. This transition indicated Korea's efforts in narrowing the gap concerning potential talents relative to the United States. Subsequently, spanning from 2012 to 2021, the SCUPI consistently maintained positive values, signifying Korea's progressive catch-up in potential talents in comparison to the United States. The positive SCUPI values during this period highlight Korea's advancements in its talent pool, illustrating the diminishing gap and suggesting the potential to even surpass the United States in terms of talent acquisition and development.

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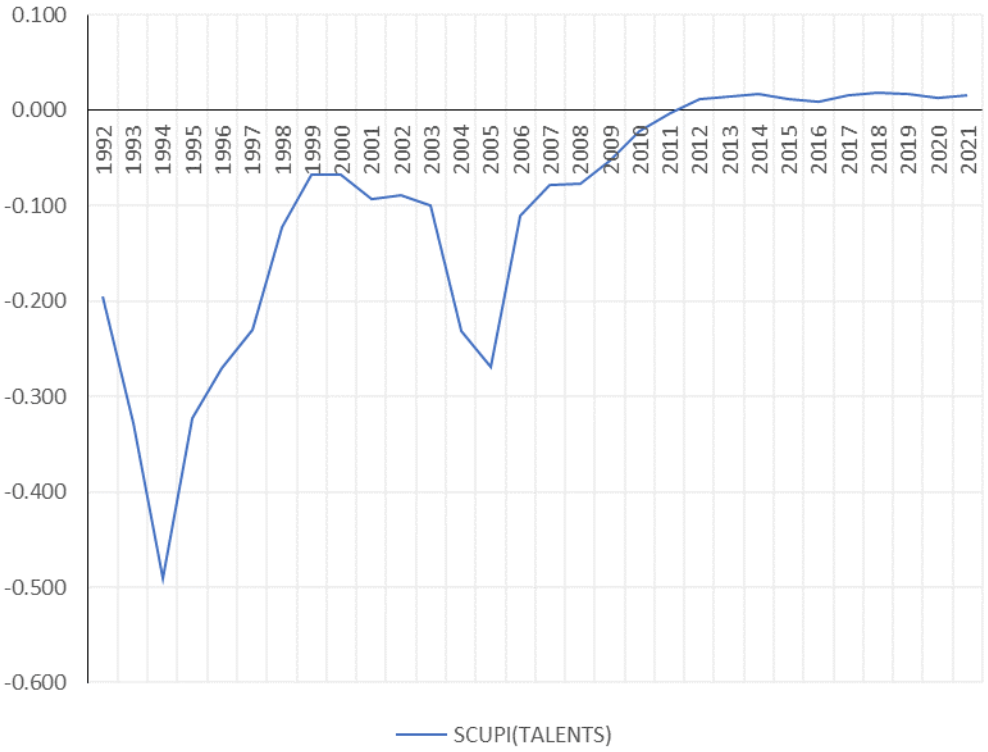
Figure 31: *Talents Catch-up Performance of Korea*



Source: *OECD, Innovation and Technology database*

Figure 32 illustrated the ICT Infrastructure Development Catch-up Performance of Korea in comparison to the USA from 2001 to 2021. Korea's SCUPI consistently reflected negative values from 2001 to 2006, indicating a substantial disparity in fixed broadband subscriptions per capita compared to the United States. However, a noticeable shift emerged from 2007 onward, showcasing a positive trend in SCUPI. This shift marked Korea's endeavour to close the gap in fixed broadband subscriptions relative to the USA. Particularly from 2011 to 2021, SCUPI consistently maintained positive values, denoting a sustained enhancement and evident reduction in the infrastructure disparity between the two nations. Remarkably, there was a significant surge in SCUPI from 2020 to 2021, implying a potential acceleration in Korea's fixed broadband subscriptions per capita,

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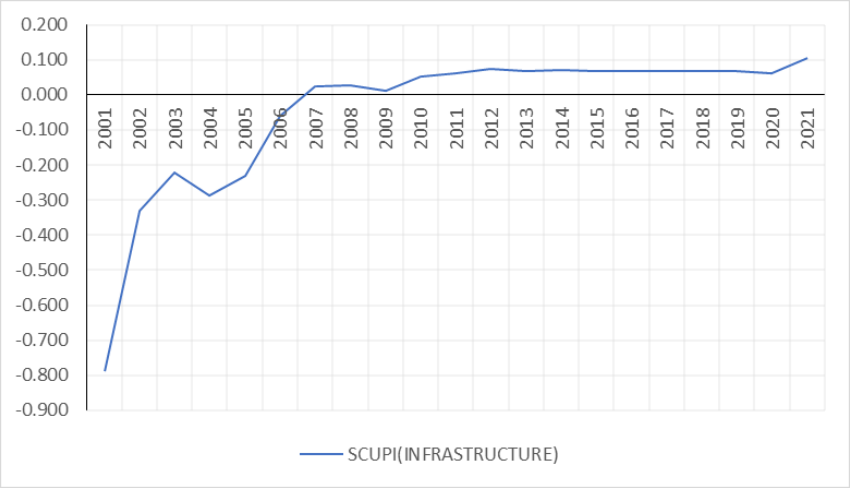
potentially surpassing those in the United States.

This trend underscores Korea's considerable advancements in ICT infrastructure, likely attributed to strategic policies, substantial investments, and technological innovations aimed at fostering robust broadband connectivity nationwide.

Figure 32: *ICT Infrastructure Development Catch-up Performance of Korea*



Source: *World bank, World Development Indicators database*

Figure 33 illustrated ITC sectors' competitiveness catch-up performance of Korea referring to the USA from 1986 to 2020. Initially, from 1986 to 2000, Korea demonstrated a consistently positive SCUPI trend, reflecting an ascending trajectory in ICT Patent numbers compared to the USA. This trend underscored Korea's dedicated efforts and advancements in technological innovation and patent acquisition, effectively narrowing the competitiveness gap within the ICT sector relative to the United States. However, the period from 2001 to 2009 saw a marginal decline in SCUPI, suggesting a potential setback in Korea's ICT competitiveness. This phase might indicate a potential saturation point in Korea's ICT innovation or a relative surge in the United States' ICT patents. Remarkably, from 2010 to 2019, SCUPI remained relatively stable, indicating a sustained yet static position in ICT competitiveness between the two nations.

Due to the COVID-19 serious impacts, there was significantly decline of the SCUPI in

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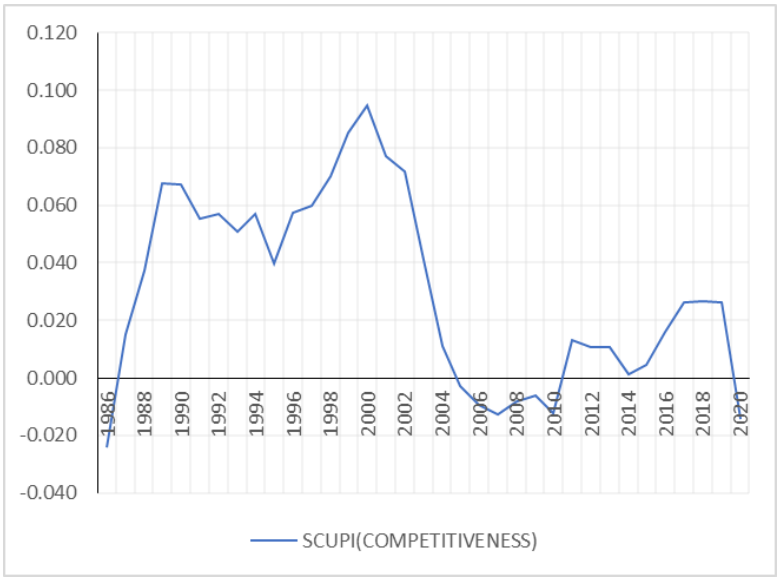
2020. In brief, this catch-up dynamic highlights Korea's historical advancements in ICT competitiveness while underscoring the present need for strategic initiatives to uphold and potentially regain its competitive edge within the ICT patent landscape in comparison to the United States.

Figure 33: *Competitiveness Catch-up Performance of Korea*



Source: *OECD Patent Statistics*

Conclusions

The success of Korea's telecommunication sector can be attributed to the consistent investment by the Korean government in R&D, talent acquisition, infrastructure development, and technological advancements. Initially, between 2001 and 2015, Korea experienced a decline in its market share compared to the USA, but a positive shift occurred from 2016 onwards, indicating a gradual recovery. In terms of R&D expenditure, Korea surpassed the USA until 2006, but a subsequent decline highlighted a diminishing advantage that persisted until 2022. Efforts to bridge the talent gap commenced in 2007, resulting in progressive advancements noted until 2021. Regarding ICT infrastructure development, Korea initially lagged behind in broadband subscriptions but significantly narrowed the gap from 2007 onwards, signaling a potential overtaking by 2021. While

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Korea initially excelled in ICT patents until 2000, a slight decline from 2001 to 2009 suggested potential setbacks, maintaining relative stability until 2019, with a decline in 2020 attributable to the impacts of COVID-19.

In the current era of information, technological advancements and knowledge innovation are experiencing unprecedented and pivotal transformations. Consequently, it becomes paramount for emerging economies to prioritize long-term research and development (R&D) investments. Such investments are instrumental in nurturing the cumulative capacity for generating new knowledge, driving technological advancements, and facilitating practical applications. Simultaneously, establishing an inclusive network ecosystem for technological and knowledge cooperation becomes crucial, encompassing public research institutions, universities, leading enterprises, and small to medium-sized businesses, both domestically and internationally.

Furthermore, sustained efforts are essential to foster widespread dissemination and utilization of emerging technologies, products, and services across diverse regions and sectors. This strategic approach could progressively empower emerging nations with increased autonomy within the global value chain. Prioritizing investments in human capital emerges as another critical imperative for emerging nations, specifically in domains such as education, technical training, and cultivating talent in cutting-edge fields.

Amidst the escalating geopolitical risks in the context of globalization, emerging nations must devise sophisticated strategies to effectively balance domestic technology initiatives with external sources of technological knowledge. This strategic approach should be aligned with their distinctive endowment positions within the global value chain. Essentially, this strategy involves not only fortifying capabilities to engage in key value-added nodes in the global value chain, driven by foreign firms (a 'made-by' strategy), but also bolstering local-global capabilities led by indigenous firms (a 'made-in' strategy).

Furthermore, considering the prevalent export structure dominated by agricultural products in most emerging economies, adopting long-term strategies becomes imperative. These strategies are aimed at accumulating capital for industrial upgrading, prioritizing sustainable industrial development over short-term profit-driven economic growth.

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6. THE CASE-STUDY OF MANIFACTURING SECTOR IN MALAYSIA

Malaysia is a federal constitutional monarchy that consist of 13 states and three federal regions which include the capital city of Kuala Lumpur and the island of Labuan off the coast of east Malaysia. It consists of two regions that are divided by the South China Sea and it shares borders with Brunei, Thailand, and Indonesia. Malaysia is strategically position in the Southern part of China. The federation of Malaysia joined the United Nations in the 1957 (World Bank,2023).

Embarking on a trajectory towards becoming a high-income nation, Malaysia is committed to enhancing its competitiveness by creating high-quality jobs and promoting greater inclusion. Malaysia is an epitomises of value for money at all cost. Essentials such as food, fuel, internal or local transportation and accommodation are reasonably priced. Malaysia has luxurious living standards, a well-developed infrastructure as well as excellent healthcare and shopping facilities (World Bank, 2022).

The economic landscape of Malaysia is diversified, with Agriculture contributing 6.3%, Services dominating at 58.6%, and Industry playing a significant role at 24.0% (World Bank, 2022). Despite challenges, the nation has successfully maintained a poverty rate of 6.2% since 2022, as reported by the Department of Statistics Malaysia household income (World Bank, 2022).

The GDP estimate reveals a growth forecast of 3.4% since 2023, signifying a substantial recovery from the pandemic-induced challenges of 2022. Malaysia's economy is globally recognized, ranking as the 25th most competitive economy in the world by the 2021 Global Competitiveness Report with an estimated budget of $430.895 billion (PPP, 2023).

Malaysia’s commodity export earnings contribute significantly to the country’s economy with valuable mineral resources such as petroleum and natural. The consumer price inflation in Malysia ranges at 2.0 in ten years leading to 2022, stands slightly below the Asian average. Despite a crisis in 1997, Malaysia's economy is setup for growth, with estimates suggesting an increase between 4 to 5% in 2024. These indicators underscore Malaysia's resilience and potential in the global economic landscape.

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Literature Review

Manufacturing is the process of transforming raw materials into tangible final products, which involves the optimization of processes to convert resources for consumer sales. Malaysia's geographic location, political stability, dependable infrastructure, flexible labor markets at affordable prices, and alluring incentives attracted the attention of multinational corporations, making it the third most trade-opening economy in the region (World Bank, 2011). The electrical and electronics (E&E) sector played a pivotal role, constituting nearly half of all trade at its peak.

Environmental challenges have become a problem to the global community due to the numerous pollutions and unpredictable climate that have occurred recently. Global civilization is becoming more conscious of the environment in order to live a better, more sustainable, and ecologically friendly lifestyle. It is projected that in midyear, Malaysia's population will be 34,308,525. (Lai et al.,2016). Accounting for 0.43% of the world's total population, Malaysia faces waste management issues in its manufacturing sector, escalating costs of waste treatment and causes environmental problems (Tsen et al., 2005; Ling et al., 2020). Educational mismatch is another concern in the industry, with a higher proportion of undereducated individuals. The workforce composition in Malaysia's manufacturing sector from 2015 to 2022 reflects this challenge (Lai et al., 2016; Rosli et al., 2013).

Malaysia approved 801 projects which created more job Opportunities. Even though there were more jobs created and more domestic investors participated, the post-pandemic boom phase that saw Malaysia's manufacturing sector investment reach its peak in 2021 had stabilized into equilibrium in 2022. The manufacturing sector in Malaysia employed over 2.72 million people in 2022 (Yusof et al,2020). Electrical and Electronics industry has been a vital economic pillar for the country and is an essential component of the manufacturing sector in Malaysia (Meng et al,.2012, Wong et al,.2009, Lai et al.,2016). The petroleum products, transportation equipment, and machinery and equipment (M&E) subsectors are major contributors to the high-value projects. Aerospace, medicines, and chemicals and chemical products are three further subsectors that hold significant growth

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potential in the future (Fay,2001).

According to this ranking for 2022, the USA has the greatest economy in the world with a GDP of 25.44 trillion dollars. China, with a GDP of 17.96 trillion dollars, is in second position. Canada ranks seventh in this ranking and is also much ahead in the international comparison. China produces 28.4% of the world's manufactured goods. China is one of the oldest civilizations in the world, and it is located in East Asia. All aspects of Malaysia's economy are changing, with the manufacturing sector leading the way up the value chain by prioritizing investments that introduce new technologies and generate highly skilled jobs (Murphey, & Stapleton,2019).

In contrast to the preceding year, the manufacturing sector ranked second in 2022, accounting for 31.9% of all authorized investments in the nation. This was overtaken by the services sector, mostly because of three massive data center projects. by a more restrained 3.9% growth from the manufacturing industry. Despite several challenges, Malaysia's manufacturing industry remained resilient throughout the year, bringing about significant transformation and generating observable benefits. For example, despite RM15 in investments, the industrial sector's development stagnated in the second quarter of 2022. China is the world's leading manufacturer, according to the US Statistics Division (Yusof et al,2020)

The nation contributes 28.4% of the world's manufacturing output, which boosts the global economy by around $4 trillion. At 1.4 billion people, it is the most populated country in the world. China is one of the greatest locations to conduct business because of its low expenses and entrepreneurial economy. China accounts for 28.7% of the world's manufacturing output. The GDP of Malaysia grew by 3.9% during 2023's first three quarters. Throughout the quarter, headline inflation remained low, coming in at 2% (2Q 2023: 2.8%).

The manufacturing sector in Malaysia has several significant sub-sectors, including petroleum, chemicals, rubber, and plastic products. meals, drinks, tobacco and electronic and electrical goods. Manufacturing in Malaysia is having trouble. Absence of creativity. Innovation and research and development involve greater risk, a longer time frame, and

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significant machinery purchase costs. The advanced infrastructure in Malaysia is one of the main advantages of investing there. Presently, Peninsular (West) Malaysia and East Malaysia are covered by a road network of approximately 140,000 km, which connects the more than 500 industrial parks and zones that are present. The longest highway stretches over 800 km, connecting to both the northern border with Thailand and the southern border with Singapore. With a current population of about 6.82 billion, there are 152 developing nations as defined by the IMF. This represents a substantial chunk of the global population, at 85.54 percent.

Table 3: *United Nations of trade and development, 2015*

Name of Country	Manufacturing output ($)	Percent of National output (%)	Percent of global manufacturing (%)
China	2010	27	20
USA	1879	12	18
Japan	1063	19	10
Germany	700	23	7
South Korea	372	29	4
India	298	16	3
France	294	11	3
Italy	264	10	3
UK	244	10	2
Taiwan	185	31	2
Mexico	175	19	2
Spain	153	14	2
Canada	148	11	1
Brazil	146	11	1
Russia	139	11	1
Federal	139	11	1
Turkey	125	18	1
Indonesia	115	22	1
Poland	100	20	1
Switzerland	93	18	1
Netherlands	88	12	1

International production sharing, or global value chains (GVCs), is the practice of dividing up production into tasks and activities that are completed in several nations. GVCs produce far more complicated goods than pins, and their operations are dispersed across

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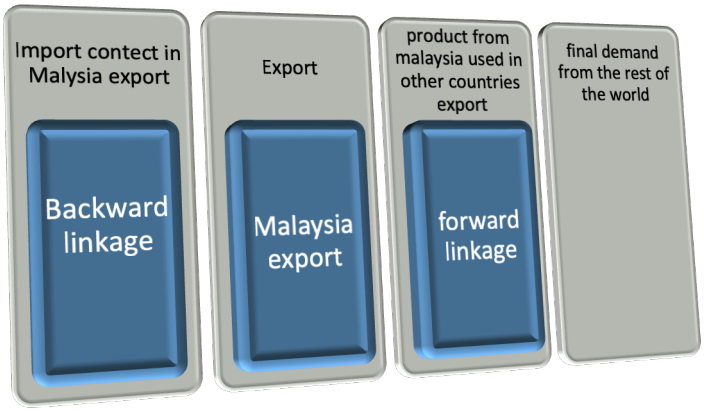
national borders rather than being limited to one spot. (Seric, & Tong,2019). For manufacturing companies, the value chain extends to the raw materials used to make products and consists of every step before the products are sold to consumers. The value chain includes design, production, marketing, and distribution. Malaysia is deeply involved in Global Value Chains (GVCs), specializing in the final stages of the production process (backward linkage). High GVC participation has reduced the impact of exchange rate movement on Malaysia's exports (Seric, & Tong, (2019).

Advanced economies, which often focus on high-value-added industries like advanced technology, financial services, sophisticated manufacturing components, marketing, and servicing, stand to gain from the expansion of global value chains. There are still winners and losers. Research indicates that trade with China and economies that contribute to its value chains has resulted in a loss of middle-skill manufacturing jobs in the United States but a gain of high-skill manufacturing and service jobs, with overall employment remaining relatively stable. There is proof that the nation's participation in the manufacturing sector's backward global value chain (GVC) is declining. Its standing in GVCs has improved, but the nation is no longer as desirable as a basis for outsourcing. Additionally, foreign value-added's contribution to the manufacturing sector's export growth has decreased. Microlevel data highlights shortcomings in technology and human resources.

Figure 34: *Conceptual Chart of Malaysia's GVC Participation*



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Structure, Specialization and Policy Mixstructure, Specialization and Policy Mix of Malaysia Manufacturing Industry

Globally, United Nations Industrial Development Organization (UNIDO) reported that world manufacturing production in 2022 continued to grow positively at a solid 3.6 per cent year-on-year in the third quarter of 2022. Malaysia, which UNIDO categorises as a middle-income industrial economy, saw manufacturing output grow at an impressive 13.4 per cent year-on-year during the same period (Shaari, Masnan, Alias & Rahim, 2021).

Development planning in Malaysia started in 1950 with the publication of the Draft Development Plan of Malaysia (Lee & Chew-Ging, 2017). The manufacturing industry in Malaysia is overseen by the Malaysian Industrial Development Authority (MIDA). MIDA facilitates and regulates investments into the Malaysian manufacturing sector. Some scholars such as Harrison, 1996; Rodríguez & Rodrik, (2001), expressed reservation for the openness policy of the Malaysia government regarding the manufacturing sector. MIDA has been criticised by one business periodical as being "preoccupied with internal bureaucratic concerns rather than the entrepreneur's needs" emphasising "rules and regulations, with less actual assistance to the business owners " (Chandran, 2009). While many studies have provided empirical evidence on the impact of trade openness and economic growth at nation level, analysis within the framework on manufacturing industries are solely lacking. Chandran (2009) notes that Malaysia appears to be a suitable case study for economic framework, given the fact that it is one of the highest growing open economies among the developing countries Chandran, 2009).

The COVID-19 pandemic significantly impacted Malaysia's manufacturing sector, with notable declines in industries such as textile, wearing apparel, footwear, and transport equipment (Kuriakose & Tran, 2020). The textile, wearing apparel and footwear industry had a decline in the manufacturing performance index (MPI) in April 2020 of nearly 74 per cent year–over-year basis, closely followed by transport and equipment, which decreased by 69.3 per cent, and wood furniture, paper products and printing, which decreased by 68.4 per cent. According to the Department of Statistics Malaysia, the manufacturing performance index dropped 37.2 per cent overall compared to April 2019. Apart from the

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three above mentioned industries, the other five industries that have declined the most due to the effects of COVID-19 are non-metallic products and basic metals (reduction by 62.7 per cent) and electrical and electronic products (reduction by 37.1 per cent) (Kuriakose & Tran, 2020).

The manufacturing sector has played a key role in the effort of developing countries to grow and prosper. This has been the experience of the Malaysian economy since the 1960s (Lee, 2019). However, since the late 1990s, the country's economy has begun to de-industrialize. Malaysia's manufacturing has been primarily export-oriented, the relative decline in the sector's contribution to the country's economy has also resulted in a decline in its participation in the global economy.

This study by (Chandran, Rasiah, Wad & series, 2009) confirms that the Malaysian manufacturing systems of innovation is weakly positioned but shows limited evidence of process innovation and not product innovation. Malaysia's total trade volume accounts for 85% of manufactured goods which is fundamental for both imports and exports. The trade of manufacturing products to and from Malaysia in the first ten months of 2019 amounted to USD 309 billion, of which exports accounted for USD 168 billion (Malaysia's Manufacturing Environment & Investment Guideline Asias Perspective).

In striving towards a high-income nation status by 2020, Malaysia's manufacturing sector remains a core sector for sustainable growth under the 11th Malaysia Plan. The manufacturing sector has played a vital role in the economic transformation in Malaysia. Malaysia has continued to attract huge investments in the manufacturing sector despite a challenging economic environment due to its highly-diversified economy, strong manufacturing foundation, developed infrastructure and connectivity, proactive Government policies and hardworking workforce .

The following are some of the specialisations applicable to the Malaysian manufacturing sector:

- Electrical and electronics: Malaysia is a major global E&E manufacturing hub. Electrical and Electronics Industry (E&E) Malaysia's E&E industry is an integral part of the manufacturing sector and has been a key economic pillar for the nation over the

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past 50 years (Liang & Lean, 2024).

- Transport Equipment: Malaysia's transport equipment industry contributes significantly to the nation's economy by providing jobs for many people involved in vehicle production and through its role in the country's logistics network. Malaysian transport equipment industry players can produce vehicles and components for all modes of travel (Nathan, Kamaruzaman & Ma'in, 2016).
- Automotive: The automotive sub-sector employs approximately 710,000 people and contributes almost RM30 billion to the nation's gross domestic product (GDP). In 2022, the Malaysian automotive sub-sector produced about 702,275 motor vehicles, a 45.8 per cent increase over 2021's figure of 481,651 (Jannah, Aqilah, Atifah, Hadfini, & Varghese, 2023).
- Shipbuilding & Ship Repairing (SBSR): The SBSR industry in Malaysia is key when it comes to maritime sector development that complements the oil and gas industry. Malaysian shipyards can build various types of small- to medium-sized vessels, and boast repairing capabilities for vessels of more than 600 tonnes of displacement (Ismail & Main, 2021).
- Basic metal products: Malaysia's basic metal products industry is a key source of inputs and raw materials for many other manufacturing industries, including M&E, transport equipment, medical devices, energy, communication devices, and scientific equipment (Rosli, Aziz, Pueh, Othman, Zawawi & Hung 2023).
- Textiles and Textile Products: The Malaysian textiles and textile products industry is highly competitive, with local manufacturers capable of producing a wide range of high-quality textiles and textile products. The global textile market size was valued at US$993.6 billion in 2021 and is anticipated to grow at a compound annual growth rate (CAGR) of four per cent from 2022 to 2030. The slowdown in the industry is in part due to the Russia-Ukraine conflict, which disrupted global economic recovery from the COVID-19 pandemic, at least in the short term, resulting from economic sanctions on multiple countries, rapid rises in commodity prices, and supply chain disruptions, affecting many markets across the globe (Farhana, K., Mahamude, A.S.F. and Mica,

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M.T., 2022)

- Leather and Leather Products: Leathermaking in Malaysia goes back hundreds of years, involving products such as musical instruments and footwear. Due to environmental concerns caused by the tannery process and the limited local supply of quality raw animal hides, most companies in the industry opted to concentrate on manufacturing leather products back in the early 1990s (Bin & Ahamat, 2021).
- Scientific and Measuring Equipment: The scientific and measuring equipment industry in Malaysia is a growing, vibrant industry that contributes significantly to the healthcare sector and R&D through the production of laboratory diagnostics platforms and measuring instruments and apparatus (Fadhil, Ismail & Alnoor 2021).
- Food Manufacturing: Globally, the food market is expected to reach US$6.4 trillion in 2022, growing to US$8.9 trillion in 2026 at a CAGR of 8.7 per cent. The nation's multicultural population plays an important role in supplying the vast regional and global demands for food and beverage products, with its processed food exports gaining market share in over 150 countries, while its certified halal products are well-received amongst the 1.8 billion Muslims world (Al-shami & Abdullah 2023).
- Furniture and Fixtures: Malaysia's furniture and fixtures industry (which is ranked among the top five furniture exporters in Asia) comprises mouldings and builders' joinery, carpentry (i.e. doors and windows), as well as furniture and associated components. Currently, the country's furniture exporters are entrenched in 160 countries while displaying an increment in both population and infrastructural reach, as Malaysian furniture products find new homes in the United Arab Emirates, Saudi Arabia, the Philippines, Russia, as well as the emerging economies of Algeria, Greece, Puerto Rico, and Libya. In 2022, Malaysia's export of furniture made of wood, plastic, metal and parts recorded RM13.9 billion, an increase from RM12.6 billion in 2021 (Ratnasingam, Khoo, Jegathesan, Wei, Abd Latib, , Thanasegaran, Liat, Yi, Othman & Amir, 2020).
- Chemicals and Chemical Products: There has been an increase in demand for chemicals and chemical products in 2022 and the industry is well on the road to

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recovery from the impact of the COVID-19 pandemic on the supply chain, logistics and foreign labour. Increasing demand can be seen in industries ranging from healthcare, cosmetics, personal care, and pharmaceuticals to E&E and transport (M. Pauzi, N.A., Cheema, M.S., Ismail, A., Ghazali, A.R. and Abdullah, R., 2022).

- Petroleum Products (including Petrochemicals): As one of the leading industries in Malaysia, the petroleum products including petrochemicals industry is highly developed, as the nation is a major exporter of petrochemical goods including olefins, polyolefins, aromatics, ethylene oxides, glycols, and polystyrene. These products remain essential to many commodities used in daily life, such as plastics, fertilisers, and apparel (Dwi Prasetyo, Putra, Bilad, Mahlia, Wibisono, Nordin & Wirzal, 2020).
- Rubber Products: The rubber products industry in Malaysia is a longstanding, well-established one, even before the nation itself came into being. Today, Malaysia is the world's seventh-largest producer and eighth-largest consumer of natural rubber. Malaysia manufactures rubber products for use in three major categories: tyres, industrial custom rubber products, and consumables such as gloves and shoes (Abdullah, Sieng, Sulaiman & Abd Rahim, 2020).

Malaysia's government adopts pro-business policies (Kheng, 2023), for example, the exemption of the 30% Bumiputera equity condition for data centre. This exemption applies to purchases of land for data centre projects that are approved by the Malaysian Cabinet for land acquisitions valued above RM20 million and is valid until 2025.

The Malaysia Government is prioritising targeted policies and sustainability initiatives aligned with ESG principles and practices. The National Investment Aspirations (NIA) which provides the framework for the New Investment Policy (NIP) is set in motion to review investment-related policies and restructure the country's investment strategies aimed at securing more high-quality, high-impact and capital-intensive projects for the nation (Norizan, Hassan & Yusoff 2021).

Malaysia's manufacturing sector policy aims to strengthen economic growth by preparing the industry towards globalization, enhancing local production of capital and intermediate

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goods, and encouraging exports. The manufacturing sector will need to further advance its competitiveness and capacity as well as position itself to take advantage of the opportunities and challenges arising from global and regional developments in trade and investment (Pertheban, et al., 2023). It is important for the government to continuously identify improvements to existing incentives as well as introduce more focused incentives to strengthen industrialization in the country to encourage investments in high value-added industries. (See: The National Policy on Industry 4.0 - Industry4WRD - provides a concerted and comprehensive transformation agenda for the manufacturing sector and its related services.)

The government of Malaysia actively engages in global agreements such as the Malaysia-Türkiye Free Trade Agreement (MTFTA) and the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP).

On 29 September 2022, the Governments of Malaysia and Türkiye signed a protocol to broaden the Malaysia-Türkiye Free Trade Agreement (MTFTA) which initially came into force on 1 August 2015. With this, MTFTA's scope is expanded to include trade in services, investments, and e-commerce− a step that would further stimulate investment crossflows between Malaysia and Türkiye (Agnelli & Tortora, 2022). Exporters from both countries are encouraged to leverage their strategic locations into the regional market Malaysia also ratified the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP) on 30 September 2022.

The ratification opens export opportunities for Malaysian companies into new markets such as Canada, Mexico and Peru− countries previously not covered by any existing free trade agreement (Smith, Smith & Perry, 2023). In addition to this, the CPTPP, which currently boasts 11 countries as its members could be further expanded through the potential agreement of additional countries such as the United Kingdom, the PRC, Chinese Taipei, Ecuador and Costa Rica, all of which have applied to join the trade pact. Furthermore, Malaysia is also pursuing active negotiations to upgrade its existing regional FTAs, namely the ASEAN-China Free Trade Area (ACFTA), the ASEAN-Australia-New Zealand Free Trade Area (AANZFTA), and the ASEAN Trade in Goods Agreement

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(ATIGA).

Malaysia has always been responsive to globally agreed tax standard reforms to foster a competitive business environment. In October 2021, Malaysia was among 136 countries and jurisdictions agreeing to a proposal developed by the OECD to establish a 15 per cent global minimum tax rate (GMTR) to curb tax evasion by MNCs shifting profits and tax revenues derived from intangible sources such as drug patents, software and royalties to low-tax countries to evade higher taxation in their home countries (Parada, 2024). The nation agreed in principle to implement the GMTR on selected MNCs and is actively involved in working group discussions to ensure participation in policies implemented by the OECD. In anticipation of the GMTR implementation in 2024, the Government is reviewing the possibility of introducing a Qualified Domestic Minimum Top-up Tax (QDMTT), which is a tax levied on the excess profits of group entities in Malaysia that have an Effective Tax Rate (ETR) of less than 15 per cent.

To strengthen and deepen domestic investments, MIDA continually undertakes these targeted strategies:

- Focus on Industry 4.0 (IR4.0) technologies: To assist local companies to adopt new technologies and achieve Industry 4.0 status through facilitation of various incentives and assistance provided by the Government – reducing dependence on low-skilled labour Focus on Industry 4.0 (IR4.0) technologies (Ahmad, Moshood & Nawanir, 2024).
- Digital adaptation: To encourage local companies to digitise production processes by embracing the Internet of Things (IoT) for online product marketing as well as reduce logistics and labour costs to optimise operational costs in the long term (Gamil, Abdullah, Abd Rahman & Asad, 2020.).
- Domestic linkage enhancement: To encourage the use of domestic inputs to expand and grow domestic supply chains and to enable the integration and extension of domestic supply chains into the region's economy and further into the global value chain, maximising the advantages of the opportunities of a borderless market (Naqshbandi & Jasimuddin, 2022).

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SMEs will have to adopt innovative approaches including benchmarking against international standards to meet the requirements of the increasingly competitive business environment. Develop unique, high-value products and services: MIDA envisions a highly complex Malaysian economy built on skills-based industries with significant productive capabilities. Equip local companies to develop sophisticated products and services through triple helix collaborations between the Government, industries and universities or technical institutes (Fadzil & Rashid, 2022).

In conclusion, Malaysia's manufacturing sector, which is guided by its strategic policies, exhibits resilience and adaptability in a dynamic global landscape, emphasizing innovation, diversification, and sustainable growth. Industry 4.0 technologies, digital adaptation, domestic linkage enhancement, and resilient SME development are the focus areas for MIDA to deepen domestic investments.

Modelling Approach, Empirical Analysis and Case Study Techniques

In this study, a rigorous quantitative methodology has been adopted to delve into the catching-up performance within the context of Malaysia's manufacturing sector. The research builds upon the foundation laid by previous studies with a similar focus, allowing for a comprehensive analysis of the intricate underlying forces at play. To conduct this investigation, secondary data has been thoroughly gathered from the World Bank's website, ensuring a robust and reliable dataset. This approach not only enhances the depth of our understanding but also enables a detailed exploration of the factors influencing Malaysia's manufacturing catch-up performance.

The macro-approach to measuring GVCs connects national input-output tables across borders using bilateral trade data to construct global input-output tables. These tables have been applied to measure trade in value added, the length of and location of producers in GVCs, and price linkages across countries. The Index of Average Catch-up measures how a country is performing in terms of both income level and economic size catch-up. It is an averaged score of a level catch-up index and a size catch-up index. The

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Catch-Up Performance Index (CUPI) is an indicator of a nation's progress in catching up to more developed countries in terms of income generation or economic activity and development, which is based on statistical data. In order to assess how successfully a nation is "catching up" to or closing the income gap from a reference country or set of countries—typically the United States. According to Vu and Nguyen (2022), one simple measure to capture these dynamics is the CUPI.

According to (Vu & Nguyen, 2022), ASEAN countries can substantially boost economic growth and catch-up through deeper regional integration and policy coordination, leveraging their advantages in scale and strategic location amidst the rise of Asia. As the catch-up dynamics among member nations become vibrant, as seen for the past two decades (1997–2017), one may expect that the convergence trend will be even more solid in the next two to three decades to come.

Beyond a basic exploration, we embark on an intricate comparison of the growth trajectories within the manufacturing industries of three distinct countries. Our lens then widens to encompass a macroeconomic perspective, with a focus on Malaysia's overall economic landscape, with particular emphasis on its dynamic and evolving manufacturing sector. The aim is to unravel the multifaceted aspects of Malaysia's manufacturing domain, taking into consideration the various industries that shape its growth, development, and contribution to the broader economic framework.

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Figure 35: *Comparison of Manufacturing growth for Korea, Malaysia and Singapore*

Figure 35 presented the manufacturing sector's growth comparison for three different countries within the same region. According to the chart, it was observed that Singapore's manufacturing sector showed a better growth improvement when compared to Malaysia and Korea Republic. The growth performance of manufacturing sector for these countries varies annually with some negative growths experienced in the three nations. Malaysia manufacturing sector showed an increase-decrease growth characteristic, whereby the highest growth was observed in the year 2000 at about 18% and the lowest growth in the year 2009 at about -8%. On the other hand, Singapore's manufacturing growth performed better in the year 2010 at about 30% growth index, and begins to decline up until the year 2015 with a negative growth of -5%. In addition, the Korea republic manufacturing industry was observed with almost zero growth in the years 2000, 2010, and 2021, respectively. However, Malaysia manufacturing industry's growth displayed almost constant growth between the year 2010 and 2019. In the year 2020, there was a decline in the growth to a negative value which was due to the covid-19 pandemic around the world. Thus, the manufacturing sector of Malaysia experienced a stable growth over the years with an

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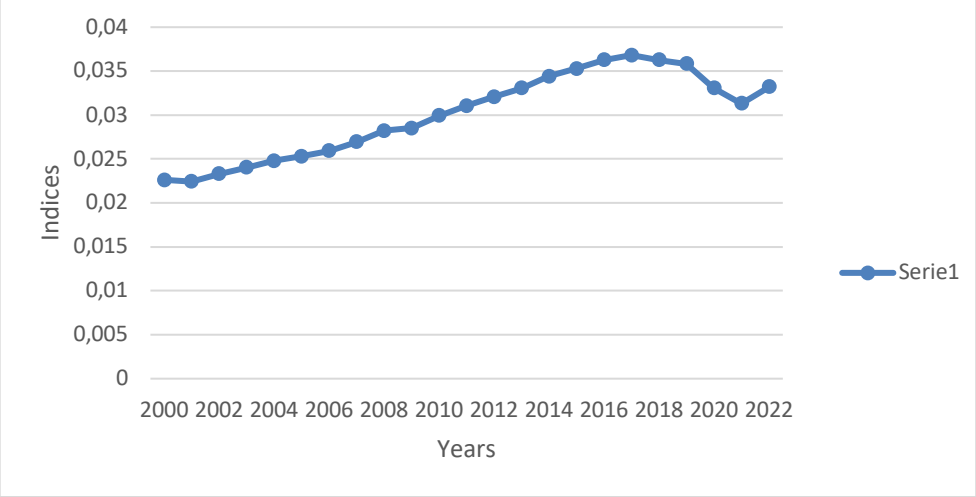
average value of 4.5% growth index.

Figure 36: *Malaysia overall CUPI Index*



The gross domestic product (GDP) of Malaysia for catching up performance is illustrated in the Figure 36. According to the chart, it was observed that the GDP performance between the year 2000 and 2022 were analysed. However, we observed that there was a tremendous increase in growth between the year 2000 and 2017, and then begins to decline which could be as a result of global economic meltdown taking place globally. The increments between the year 2000 and 2017 were 2.25% and 3.75%, respectively. There was a further declination up until the year 2021, which was exacerbated due to the global pandemic, covid-19. Thereafter, there was a significant increase in growth with about 3.4% of post covid-19. Having said that, there were thirteen countries including the United States as the benchmark for the GDP growth analysis. Therefore, the economy of Malaysia is maintaining its growths on the global perspective.

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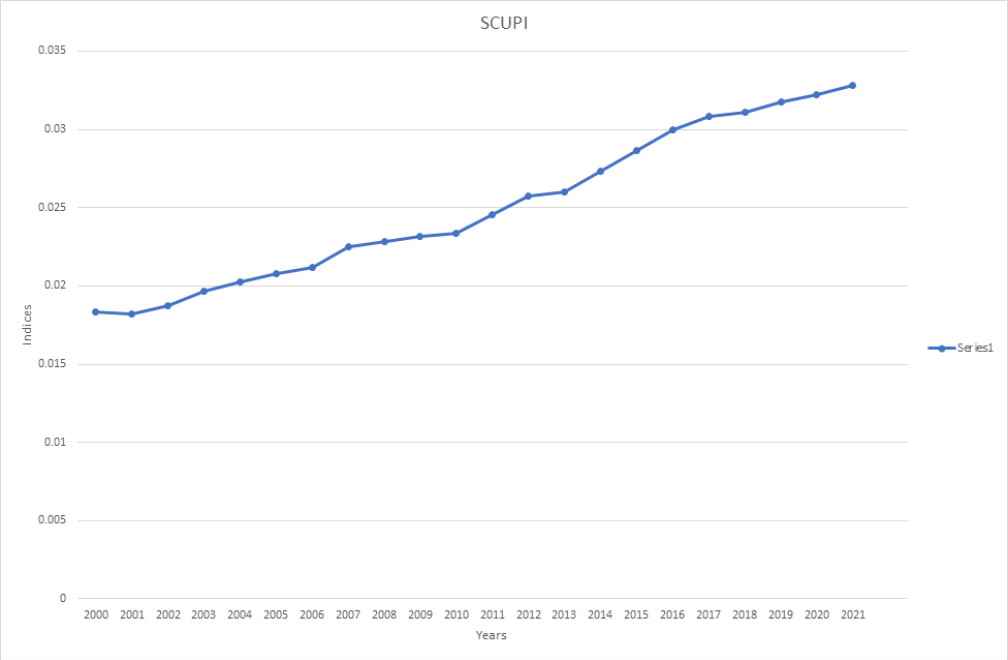
Figure 37: *Malaysia Manufacturing SCUPI Index*



The manufacturing sector for catching up performance index (SCUPI) was evaluated and presented in the Figure 3. SCUPI was evaluated over the years between the year 2000 and 2021, and it was observed with a linear curve performance between 0.019 and 0.033, respectively. This is simply evaluated taking other countries into consideration, such as the United States, Germany, China, Korea, Singapore, etc., by obtaining both the minimum and maximum values of performance indices to analyse the Malaysia manufacturing sector. In addition, this performance increases yearly, which shows that there is/was an annual improvement in the sector.

Conclusion

Malaysia is one of the most progressive countries in the Asian continent. The country has shown steady GPD growth over the past two decades which is very impressive particularly because Malaysia indicates long term stability compared with other Asian counties.
The manufacturing sector has undergone significant challenges and developments, yet it

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remains one of the major contributors towards the country's GDP. Its role in Malaysia's economic landscape is evident in its diverse sub-sectors, ranging from electrical and electronics to automotive, textiles, chemicals, and food manufacturing. The CUPI for this sector shows steady growth over the last decade and CUPI growth indicates potential as it compares Malaysia with other countries which are leading in manufacturing.

Data from the world bank was used to gain insight into Malaysia's manufacturing sector's economic Catchup journey and its role in the global value chain. Although we observed steady growth year on year for the last two decades, Malaysia is still leading compared to other counties that are high in manufacturing such as Singapore and Korea.

Despite facing challenges such as the impact of the COVID-19 pandemic on certain industries, Malaysia has demonstrated resilience, with the government adopting pro-business policies and implementing initiatives to strengthen the sector.

The empirical analysis, based on catch-up performance indices, provides insights into Malaysia's progress in closing the income gap with other countries. The manufacturing sector's growth comparison with neighbouring nations, such as Singapore and South Korea, illustrates Malaysia's steady and resilient performance over the years.

Lastly, Malaysia's manufacturing sector stands as a key driver of economic growth, job creation, and global competitiveness. The nation's commitment to embracing technological advancements, sustaining growth through strategic policies, and actively participating in global value chains positions Malaysia as a dynamic player in the evolving landscape of international manufacturing. As the nation navigates through challenges and opportunities, the manufacturing sector remains a cornerstone in shaping Malaysia's economic future.

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7. THE CASE-STUDY OF GREEN ENERGY SECTOR IN SOUTH AFRICA

The first electric lighting in South Africa was a street light that was introduced in the late 19th century in Kimberley, a city in the Northern Cape province in 1882, followed by Cape Town in 1895, when a power station for electricity generation was established (Royal Society of South Africa, 2015:1870-1930). This was the beginning of the country's organised power generation which was not sustainable because the electricity bills were excessive due to the tiny size and inefficiency of the power plants and the inadequate connectivity between the users (Royal Society of South Africa, 2015:1870-1930). As a result, the concept of a central electrical enterprise began to emerge; nevertheless, it was not realised until 1906, when the Victoria Falls Power Company (VFP) was founded as a result of the joint acquisition of Rand Central Electric Works (RCEW) and General Electric Power (Akinbami, Oke & Bodunrin, 2021). By 1915, VFP had a total installed capacity of more than 160 MW spanning thermal power units, with a control centre at Simmerpan (ESCOM 1923 - 1929). Recognising the importance of power, the Transvaal colonial administration enacted The Power Act, which gave the government the authority to expropriate privately-owned electrical firms after 35 years (Akinbami, Oke, & Bodunrin, 2021). Following the passage of The Power Act, a South African electrification study enabled the promulgation of the Electricity Act of 1922, which resulted in the founding of the Electricity Supply Commission (ESCOM) in March 1923 (Royal Society of South Africa, 2015:1870-1930). In 1923, ESCOM, known in Afrikaans as the "Elektrisiteitsvoorsieningskommissie (EVKOM)," aided in the electrification of the railway as well as the establishment of additional power plants throughout South Africa (Moore,2019). The Malieveldspruit hydro station was built in 1925 as a temporary alternative to the Sabie River Gorge plant, which became operational in 1927; the two plants were ESCOM's first pair of plants to be built (ESCOM, 1923-2023). ESCOM built more facilities, and by 1929, the company had sold 800 million units of electricity (ESCOM 1923 - 1932). ESCOM bought VFP and Kimberley's central power stations to meet increased energy demand in 1948 and 1950, respectively. In 1951, the Rural Electrification Department was established to deliver electricity to rural South African communities

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(Boers, 1985). The country continued to expand its electricity generation infrastructure, constructing more power stations to meet growing demand, such as the Hendrina power station which is the largest-scale coal-fired power station, which began operation in the 1950s. South Africa launched the Renewable Energy Independent Power Producer Procurement Program (REIPPPP) in 2011, to stimulate private investment in renewable energy projects (Eberhard & Naude, 2016). Eskom experienced challenges due to aging infrastructure, financial difficulties, and capacity limitations, resulting in intermittent power supply disruptions, sometimes known as load shedding (Roy-Aikins, 2016). Despite these obstacles, South Africa has continued to invest in renewable energy projects such as wind, solar, and concentrated solar power (Akinbami, Oke & Bodunrin, 2021). The 2019 Integrated Resource Plan (IRP) configured the country's energy mix and future objectives, with an emphasis on decreasing coal dependency and increasing renewable energy capability (Eberhard & Naude, 2016).

Global Value Chains (GVCs) and its importance in the economies

The term “value chain” is conceived in business management studies. Porter in 1985 tailored the concept as “a basic framework for developing a corporate strategy to promote firm competitiveness by directing attention to the entire system of activities involved in producing and consuming the product”. The value chain describes the full range of activities that firms and workers perform to bring a product from its conception to end use and beyond. This includes activities such as research and development (R&D), design, production, marketing, distribution and support to the final consumer (Gereffi and Fernandez-Stark, 2016). Understanding a firm's value chain is necessary to grasp the scope of GVCs. According to Jones et al. (2019), a value chain can be divided into five main activities: operations, marketing, sales, outbound logistics, inbound logistics, and post-sale service. Pietrobelli and Staritz (2013), assert that GVC approach offers a helpful analytical framework for examining global production processes, governance frameworks, and the allocation of risks, rewards, and activities within the global economy. The global economy is becoming more and more centered around GVCs, that are responsible for a

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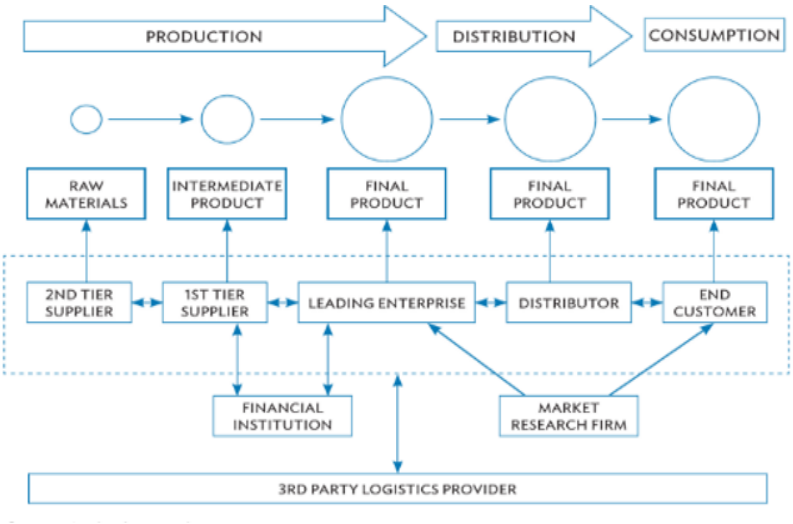
growing portion of employment, global GDP, and international trade (Gereffi and Fernandez-Stark, 2018). Since goods and services used as inputs in cross-border production processes are essential to GVCs, it is critical to distinguish between final and intermediate use in customs trade statistics. GVCs cover every action a business takes, domestically or internationally, to launch a product and see it through to completion. International production sharing, or GVCs for short, is the practice of splitting up production into tasks and activities that are completed in several nations (Seric & Tong, 2019). Production was subsequently dispersed into networks spanning numerous locations, which had an impact on the advancement of industry. A simplified GVC structure with its essential components is shown in Figure 38.

Figure 38: *A simplified Global Value Chains structure (Abe, 2016)*



According to Xiao et al., (2017) the rise of global value chains (GVCs) is characterised by outsourcing, fragmentation production, and trade in tasks and has been considered one of the most important phenomena for the 21st century trade. Many factors that enabled fast GVC integration since its first unbundling have worked in reverse in the last decade, contributing to the decline observed in the data (Cigna et al., 2022). These factors include 1) rising protectionism, 2) a decline in FDI, 3) enhanced volatility in transportation costs

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and energy prices, and 4) rising labour costs. Cigna et al. (2022) further argue that ICT developments unequivocally boosted GVC participation. GVCs have played a critical role in transforming business sectors in many developing countries by allowing specialisation in certain activities and stages of production (Qiang et al., 2021). The three key growth drivers for GVCs are resource endowment, market access, and efficiency maximization (Abe, 2016). Greater exposure to international trade improves productivity by increasing competition, expanding product markets, and improving access to production inputs (XING et al., 2021) (Xing et al., 2021). GVCs have enabled many developing countries to increase their participation in global trade raising their productivity, although many countries and regions are still left out (World Bank, 2017). Extant research about global value chains (GVCs) has focused on its economic effects, while the innovation effects of GVCs remain understudied, especially for developing countries. The study by Yang et al., (2020) showed strong evidence that GVC participation has an inverted U-shaped effect on innovation performance, whereas the effect of GVC position on innovation performance is positive. The study also found that the interaction effect of GVC position and industrial agglomeration positively influences innovation performance, while the interaction effect of GVC participation and industrial agglomeration was negative. Innovation was also found to be a robust driver of firm GVC participation (Reddy et al., 2021).

The new digital technologies have considerable potential to disrupt how and where activities are located and organised within GVCs, and who captures the value-added within those chains (Strange & Zucchella, 2017) Automation represents a threat to the position of some developing countries in GVCs and highlights the need to move beyond the dichotomy of off-shoring/re-shoring analysing how automation might drive the restructuring of GVCs with varied outcomes in production locations (Azmeh et al., 2022). China's role in GVCs has changed fundamentally from competing solely as an export platform or outsourcing destination for low-priced and low-tech consumer goods. Instead, China now seeks to become a leader in high-technology sectors linked to advanced manufacturing, cloud computing, artificial intelligence, electric vehicles, and new e-

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commerce and internet-related production networks, while lessening its dependence on the United States. and other traditional export markets by focusing on its domestic market and emerging regional markets (Gereffi et al., 2022). Jones et al. (2019) outlines the following key approaches for the analysis of GVCs:

Table 4: *Major global value chain (GVC) analytical approaches*

Analytical approach	**Description**	**Measurement method**
Supply chain management	A business analytical framework from the firm's perspective on how a firm can enhance competitiveness in the context of GVCs	Specific business/industry expertise
Industry or product case	In-depth GVC analysis from the industry's perspective, such as value distribution along a supply chain, key players, the main characteristics of the chain, etc	Micro-level firm survey, refined Broad Economic Categories to trade statistics
Input-output-based analytical approaches	Quantitative analysis from macro perspectives, by applying the input-output framework to measure a country's specialization in global production networks and its GVC participation	Trade in value-added (TiVA) measurement based on inter-country input-output tables.
Other analytical approaches	Applications of general and partial equilibrium models, as well as gravity models, for GVC-related analysis	Industry or firm data; trade statistics; inter-country input-output tables, etc.

Knez et al. (2021) proposed a comprehensive methodology of value chain analysis in the international input–output framework that introduces a new measure of value chain participation and an extended typology of value chains, with the novel inclusion of

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domestic value chain to address the extent of fragmentation of purely domestic production. This methodology allows one to distinguish and disaggregate all production activities into the categories of no value chain, domestic value chain and global value chain. According to Johnson (2018), the macro-approach of measuring GVCs connects national input-output tables across borders using bilateral trade data to construct input-output tables. The micro-approach uses firm-level data to document the how firms' source input decisions, links import and export participation, and organize multinational firms production networks (Johnson, 2018). The challenge with GVCs measurement is the availability of comprehensive, recent data. Although is a slow process, there is a gradual improvement in data sources however, by the producers of official and semi-official statistics (Sturgeon, 2019). The production of smart phones with sophisticated inputs such as semiconductors and processors proceed in another country and then assembled in a different country and received after sales service in a different country has made GVCs very complex to manage (Bank, 2017). GVCs are difficult to measure due to interlinked cross border relations of goods, services, labour and capital at the level of the individual enterprise (Nielsen, 2018).

"Catch up" refers to the process of progressing to a level equivalent to or on par with other countries, especially after the country has fallen behind in some way. Catching-up refers to closing a gap in sectors that are lagging behind and then working to reduce the difference (Chandran, Baskaran, & Selvarajan,2023:1-6). With its renewable energy initiative, which includes the renewable energy independent power producer (REIPP) procurement program, South Africa's green energy sector is catching up to the trend of switching to alternative energy solutions (Ndlovu, 2020). In contrast to the global trend toward clean energy, coal continues to dominate the nation's power generation. Despite the establishment of a national green energy project, though, and its price has increased by 11.5% (Ndlovu, 2020). Due to South Africa's propensity for drought, a significant increase in the country's current 3% share of local hydropower generation is not practical. Other renewable energy technologies, such as tidal and geothermal power generation, are only effective in a few locations and are not widespread in South Africa, compared to

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solar and wind. Currently, these sources account for 8% of South Africa's total renewable energy (Ibrahim, Ayomoh, Bansal, Gitau, Yadavalli & Naidoo, 2023).

Particularly when considering economic growth and industrialisation, the concepts of the Global Value Chain (GVC) and the catching-up approach are intertwined (Pietrobelli, 2021). Leveraging and integrating into global value chains is a common strategy used in a "catching-up" approach to expedite economic growth and development (Pietrobelli, 2021). The connection between the catching-up approach and the global value chain is the idea that participation in global production networks can spur economic growth. By allowing them to utilise outside resources, learn from more seasoned players, and gradually advance up the value chain, it aids countries in catching up in terms of economic and industrial development. The chances for specialisation, technology transfer, and learning that come with joining global value chains are what link GVCs to the catching-up strategy. By participating in GVCs, developing nations can gain skills and knowledge that will help them close the development gap with more developed economies. In the context of green energy, catching up entails integrating new technologies into the global value chain. Benefits from this integration include market access, knowledge transfer, and teamwork, all of which support the global green energy industry's expansion and sustainability. Innovative renewable energy projects, such as massive solar and wind farms, have been implemented in South Africa. These initiatives make better use of the nation's plentiful renewable resources by utilising technological innovations.

South Africa's Energy Resources Overview

The Electrical Supply Commission (ESCOM) experienced major disruptions in 2022, South Africa with more power outages, hurting production throughout a wide range of industries (Olunloyo and Moloi, 2023), leading to R1 billion in load-shedding engendered expenditures each day (Resbank, 2019). The country loses R900 million per day with Eskom scheduled stage 6 of load-shedding. According to the Reserve Bank's monetary policy, and the central bank will lower GDP growth by 0.3% in 2023, showing that the blackout influenced the economy's growth. The overall system demand in 2022 was 5.2

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TWh (2.2%) lower than it was in 2019. Coal continues to dominate South Africa's energy mix, accounting for 80% of total consumption. Coal remains the dominant energy source in South Africa, accounting for 80% of the total system load. Renewable energy technologies (wind, solar PV, and CSP) supplied 6.2 GW of installed capacity, accounting for 7.3% of the total energy mix in 2022. It was the first year that solar (PV and CSP) generation output decreased (CSIR, 2023). According to the International Renewable Energy Agency (IRENA), Africa's total final energy consumption in the industry sector and electricity demand was projected to climb from 23% to 49% by 2030 (IRENA, 2015). The main, shared goal of industrial businesses and government bodies is to reverse this trend. With so much reliance on industrial-scale production to generate economic activity, it is critical to improve or maintain plant output while applying new energy-efficient processes. Implementing energy-efficient techniques is a great way for businesses to cut operational costs (Gaggero et al., 2023).

Coal-fired power plants in South Africa provide approximately 85 percent of the country's electricity. Despite environmental concerns, coal will continue to supply the majority of South Africa's power for the next decade, but renewables will rapidly expand their share (International Trade Administration, 2023). The energy mix for South Africa's electrical supply as of the end of 2022 is depicted in Figure 1 from a report by the Council for Scientific and Industrial Research (CSIR) (Pierce & Le Roux, 2022). South Africa is dedicated to diversifying its energy mix to reduce reliance on a single or few primary energy sources. The extent to which the current coal fleet is retired due to its design life may provide a different energy mix than the current balance. Before 2030, the majority of system requirements will be required for incremental capacity augmentation (modular) and flexible technology to supplement current installed inflexible capacity (South African Department of Mineral Resources and Energy, 2019). The goals set in the National Development Plan (NDP) and the Integrated Resources Plan (IRP) aim to drive South Africa's unbiased energy transition.

According to the NDP, South Africa projected that by 2030, that the availability of an adequate supply of energy and liquid fuels will ensure that economic operations and

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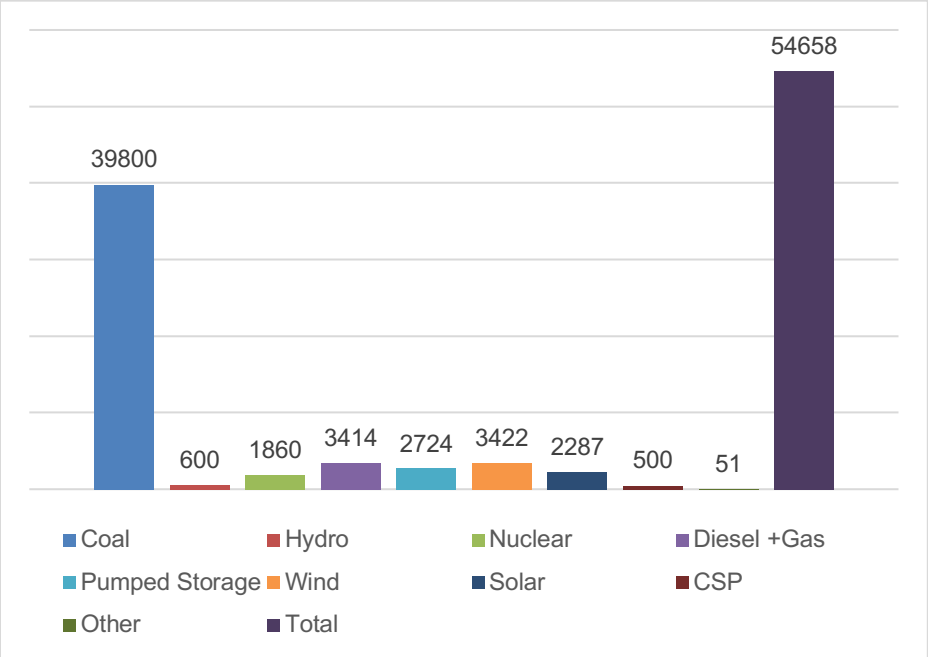
welfare are not disrupted by power outages and that at least 95% of South Africans will have access to the grid or off-grid electricity (Harrison & Sadhaseevan, 2022).

Figure 39: *The Council for Scientific and Industrial Research (CSIR) reported South Africa's Energy Resources in 2022 (Pierce & Le Roux, 2022).*



Overview of Green Energy Sector in South Africa

As concerns over climate change and the need to diversify the nation's energy mix grew in South Africa in the late 1990s and early 2000s, so did its interest in green energy. During this time, the government started debating its plans and policies for renewable energy (Gielen, Boshell, Saygin, Bazilian, Wagner & Gorini, 2019). A significant step toward integrating renewable energy sources into the nation's energy mix was made in 2011 with the establishment of the Renewable Energy Independent Power Producer Procurement (REIPPP) program (Eberhard, 2014). The private sector was encouraged to invest in renewable energy projects like wind, solar, biomass, and small hydropower with the aid of this program (Eberhard, 2014). The REIPPP program gained momentum as early as 2010,

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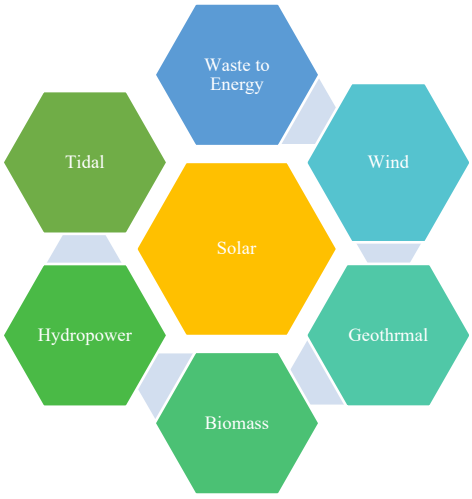
which created of numerous renewable energy projects across the country (Renewable Independent Power Producer Programme, 2023). The document presents includes the emergence of other renewable energy (RE) technologies such as solar PV, wind, biomass, and concentrated solar power (CSP) that are present in all of South Africa's provinces (Eberhard & Naude, 2017). Regarding the deployment of RE (solar PV, CSP, wind, and biomass) in South Africa, the Northern Cape region came out on top among all the provinces, closely followed by the Eastern Cape and the Western Cape Provinces. Like the majority of other nations, South Africa recognises the value of using renewable energy (RE) sources to supplement or replace its fossil fuel-based energy sector (Mukumba & Chivanga, 2023). Consequently, steps have been taken to diversify the nation's energy mix, culminating in a published white paper in 2003 outlining its plan to transition to using RE sources (biomass, wind, solar, and small-scale hydro) to produce 10 TWh of electricity.

Figure 40: *An overview of the RE sector implementation in South Africa*



This emphasised among other things, a rapid reduction in greenhouse gas emissions (GHG) across all sectors to keep global warming to 1.5°C, by providing a clear plan to promote the mitigation agenda between now and 2026 in South Africa. Following that, in May 2011, an integrated resource plan was released, which set a new aim of adding 17,800 MW of renewable energy to the energy mix by 2030 (Eberhard & Naude, 2016).

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The REIPPP was an ambitious program for RE generation in South Africa, with three primary themes focusing on reducing CO2 emissions, improving generating capacity, and providing an avenue for economic growth (Eberhard & Naude, 2016). South Africa has struggled to incorporate renewable energy sources and balance them with its coal-heavy energy infrastructure (Hanto, Schroth, Krawielicki, Oei & Burton, 2022.). Wind and solar power's erratic nature created a technological barrier to the grid's stability. Despite all of the hurdles, green energy is catching up and producing economic development and job opportunities, as well as reducing carbon emissions and combating climate change. In 2020, green renewable energy contributed 10.5% of South Africa's power. This proportion will climb to roughly 11.5% once additional plants are constructed (The Council for Scientific and Industrial Research, 2022). Renewable energy technologies (wind, solar PV, and CSP) supplied 6.2 GW of installed capacity in 2022, accounting for 7.3% of the global energy mix in the year 2023 (The Council for Scientific and Industrial Research, 2022). The Sub-Saharan Africa (SSA) region is at the moment engrossed in the web of an energy crisis and undisputable socio-economic deficits. It is obvious that the entire Africa region is naturally blessed with renewable energy resources and the SSA region is even richer from a sub-regional perspective. The poor state of renewable energy application highly rests on the poor level of technological applications and insufficient energy infrastructural development to cater to sustainable uses of resources (Aboagye et al., 2021). The rising energy demand has started to overwhelm the existing power-generating plants in South Africa. The South African road toward widespread adoption of renewable energy (RE) technology demonstrated a mixture of government policy initiatives, which converged with market forces between 2008 and 2012 to deliver an unprecedented, world-class programme. South Africa is well positioned in that, over and above its rich coal resources, it is also well endowed with non-depletable RE sources, notably solar and wind (Department of Energy, 2015). According to Akinbami et al., (2021), South Africa is endowed with enormous biomass, wind and solar energy potential however, in the contrast, coal remains the cheap primary fuel source which is but deleterious to the environment. The South African power system is characterized by large

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power stations that are concentrated in the interior of the country near the mines and industries of Gauteng province, and long transmission lines down to coastal areas. Coal supplies approximately 70 percent of the country's primary energy and more than 90 percent of its electricity (Eberhard and Naude, 2016). To date, a total of 64 projects have been awarded to the private sector, and the first projects are already on line. Private sector investment totalling US$14 billion has been committed, and these projects will generate 3922 megawatt (MW) of renewable power Eberhard & Naude, 2016). The Integrated Resource Plan for electricity (IRP) provides South Africa's long-term plan for electricity generation calls for 37696 KMW of new and committed capacity to be added between 2019 and 2030 from an adverse mix of energy sources and technologies as ageing coal plants are decommissioned and the country transitions to a larger share of renewable energy. By 2030, the electricity generation mix is set to comprise of 33364 MW (42.6%) coal, 17742 MW (22.7%) wind, 8288 MW (10.6%) solar photovoltaic (PV), 6830 MW (8.7%) gas or diesel, 5000 MW (6.4%) energy storage, 4600 MW (5.9%) hydro5, 1860 MW (2.4%) nuclear and 600 MW (0.8%) concentrating solar power (CSP) (DoE, 2018). In 2021, 25 successful bidders of independent power producers (IPPs) were announced. These IPPs comprise 12 wind farms and 13 solar PV projects, with total capacities of 1 600MW and 1 000MW, respectively. The 12 wind projects selected have a weighted average fully indexed price of R495.22/MWh, while the 13 selected solar PV projects have a weighted average fully indexed price of R428.79/MWh. The 25 projects are expected to create a total of 13 903 jobs, of which 7 743 jobs will be created during the construction period, and a further 6 160 jobs during the operations period of the 20-year PPA term. Of these, 72% of jobs will be for South African citizens (NERSA, 2021).

Analysis of The Green Energy Sector in South Africa

Renewable energy investment will be a critical business decision in 2023 and beyond because it is the most direct way for South Africa's private firms to improve their energy security status. Aside from the recently announced solar incentives for businesses and people, South African legislation already includes provisions for several green subsidies,

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incentives, and reliefs designed to promote and compensate firms for implementing climate-change mitigation measures. Among the specific incentives provided by the Income Tax Act are benefits related to energy efficiency savings, the purchase of renewable electricity-producing equipment, and the acquisition of a new and underused environmental treatment and recycling asset. Power shortages are expected to decrease potential real GDP growth by five percentage points in 2022. This has cost the country over 600,000 potential employment. Load-shedding has a wide range of negative effects on the economy, including decreased consumer confidence, which weighs on retail purchasing; lower corporate confidence, which influences investment decisions; and contaminated international perceptions, which hinder foreign investment. Beyond the GDP, society faced greater criminal risk as a result of down security systems, longer journeys due to delayed transportation, and unreliable communication due to slower mobile telecommunication services, among other difficulties (PWC, 2023).

South African homeowners and businesses installed 1,500 MW of solar generation capacity in 2022, with a total installed solar capacity of 4,550 MW at the end of last year falling outside of the Renewable Independent Power Producer Programme (REIPPP). According to the South African Photovoltaic Industry Association (SAPVIA), another 2,300 MW will be added in 2023, bringing the total capacity to 6,850 MW.

This is nearly equal to the anticipated REIPPP-related capacity of 6,952 MW. The concept of net billing is one of the benefits that could potentially release additional solar installation in business and residential buildings. Prosumers (those who both create and use energy) would be compensated depending on the actual market value of electricity. This is accomplished by balancing the surplus that prosumers put into the grid with what they consume to keep their lights on. Alternative systems, such as a feed-in-tariff (FiT), operate on a similar economic model, but with the added benefit of compensating excess energy fed into the grid at a predetermined tariff.

Productivity change in Africa is deconstructed into two components: technological change and technological catch-up.

In our analysis, we used the World Bank Development Indicators (WDI) dataset to

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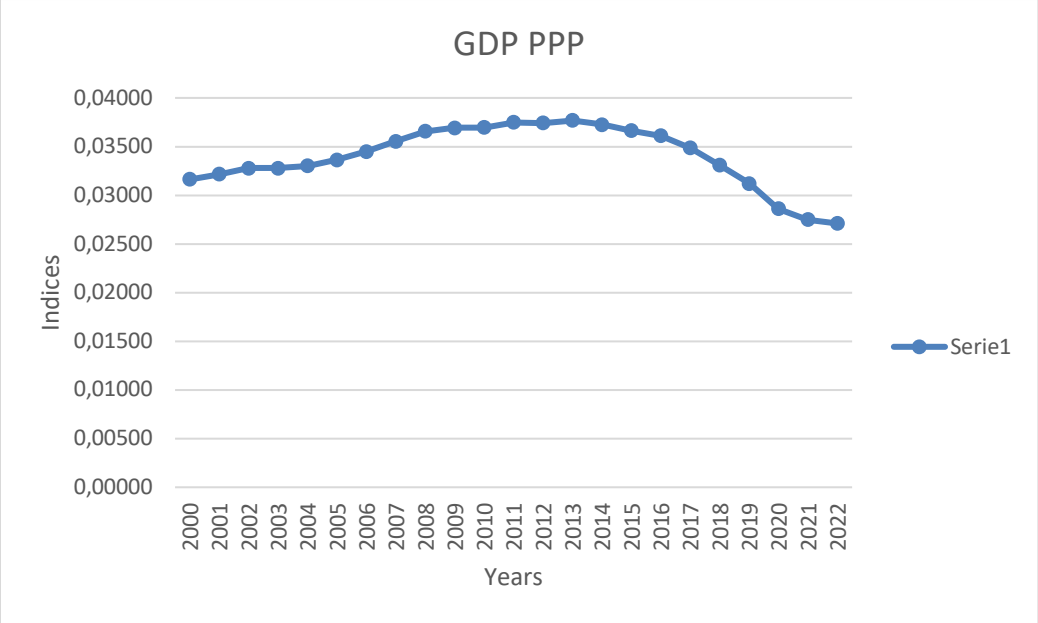
compute the CUPI over a twenty-year period (2000-2022) for all sample countries with available data on per capita income (measured in PPP US$ at constant prices). This data could be made available on request.

Figure 5 depicts the CUPI which is based on the GDP PPP for South Africa from the year 2000 to 2022. The sample size or the number of countries considered in the calculation is 12 which included USA, Italy, Costa Rico, Malaysia, Germany, China, Australia, Indonesia, Switzerland, Korea Republic and Singapore. The criteria used for the selection of the countries were mainly the availability of data for the sector and the years of interest.

Figure 41: *CUPI for South Africa between 2000-2022 (WDI, 2022)*



The analysis was done for 23 years starting from the year 2000 up to 2022. In 2000 the CUPI was just above 0.03, in the calculation, the country with the best GDP was the USA and Costa Rica had the least. The CUPI shows a steady growth from 2000 up to 2013. The positive growth in economic activity is believed to be attributed to the good policies that the country has and the stability in governance. The economic growth for SA took a

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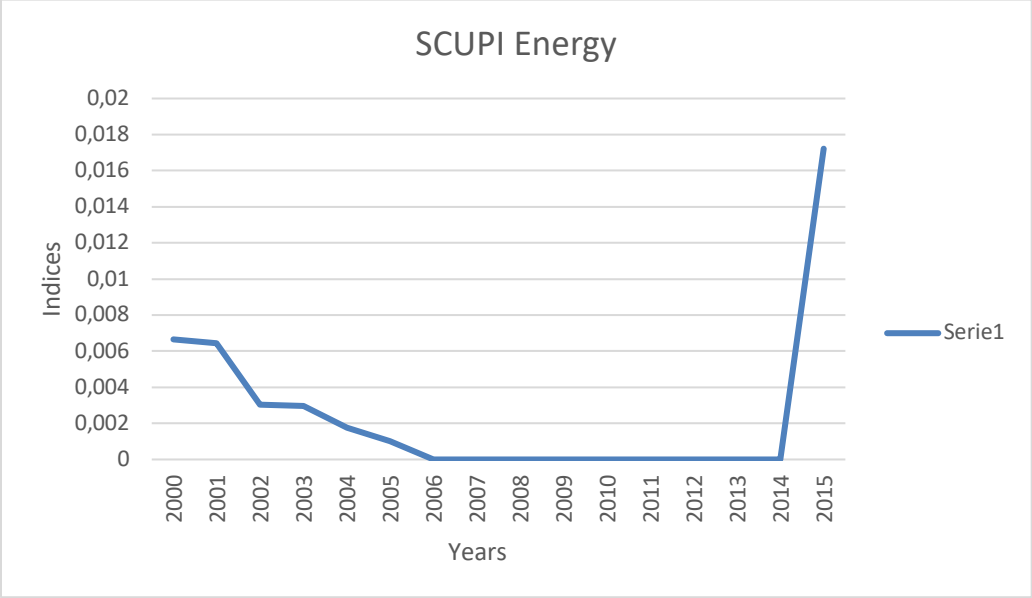
dive in 2014 and it has been declining since then. In 2021 and 2022 the CUPI showed some stability and it is believed that the index would improve due to renewed policies and investment in manufacturing sectors such as railcar manufacturing which is showing some growth. It is worth noting that the CUPI index was higher than that of Costa Rica and countries such as Malaysia for the better part of 2000 to 2011.

Figure 6 depicts an overview of the energy sector catch-up index for South Africa. The analysis considers the year 2000 to 2015 and this was due to the availability of data from the WDI database. This analysis takes into consideration the same countries included in the CUPI analysis.

Figure 42: *Sector Catch-Up Index for SA (Energy) (WDI, 2022)*



The SCUPI analysis in Figure 6 shows that South Africa was lagging behind in terms of moving into the space of green energy. The indicators used for this analysis was the contribution of the country in terms of renewable energy. Although there are SDG goals set out most countries are not aligned to this in terms of addressing the climate change challenges through the use of green energy. The SCUPI for the energy sector was

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declining since 2000 and it was almost 0 for the year 2006 to 2014. The graph shows a sharp increase from 2014. This increase might be attributed to the investment in Independent Power Producers (IPPs) that are growing in terms of numbers. The IPPs will generate energy from solar as well as wing farms which will reduce the effect of load shedding that the country is struggling with.

Overall, we could say that SA's CUPI as well as the SCUPI in the energy promises to be growing, however the speed at which this is happening should be a cause of concern.

Climate change recent development Sustainable Development Goals (SDGs)

At the 27th United Nations Climate Change Conference (COP27) in Sharm el-Sheikh, Egypt, the Sustainable Development Goal (SDG) Pavilion brought together global experts and policymakers leading the implementation of climate action and the Sustainable Development Goals for discussions on how to accelerate action across both the 2030 Agenda and the Paris Agreement. The Summit gave the negotiators the political impetus and direction they needed to make COP27 a success, including the historic choice to create a Fund to help developing nations deal with the loss and damage brought on by climate change. The South African government emphasized the need for the global financial infrastructure to undergo fundamental change, modernization, and reform, as well as for the multilateral development banks to be reformed to make them suitable for promoting Sustainable Development and Just Transitions. There were hints that the South African government will soon choose a project manager who would oversee carrying out the Just Energy Transition Investment Plan (JET IP) 2023-2027 once the Presidential Climate Commission finished its work on stakeholder engagements. This agreement on a four-year work program includes at least two global dialogues and an evaluation of the program's viability (after 2026) of the four years. The IPCC WGIII report and the IPCC 2006 Key Emissions Sectors will both be covered under the Mitigation Work Program. The Conference of the Parties to the Paris Agreement (CMA) will decide every year for the next four years. The agreed-upon content in the crucial Cover Document presented the climate problem, its remedies, and the need for broader financial sector reform in terms of

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the sustainable development objectives, just transitions, and leaving no one behind. The demand for multilateral agreement on making financial flows compatible with routes to low-emissions and climate-resilient economies may create new investment opportunities in Africa for clean energy projects, which are essential for tackling energy poverty on the continent. To decide at COP28 in 2023, it created a Transitional Committee to work on the details of this fund.

The link between energy and climate change is quite strong, with the greenhouse gas emissions from energy production becoming a substantial contributor to global warming. Climate change causes land degradation, destructive storms, and ecosystem alterations. Lack of access to contemporary forms of energy encourages encroachment into natural ecosystems in some areas, as people need to gather biomass for energy. More frequent and strong extreme weather events due to climate change pose a serious risk to supply in nations that rely primarily on hydropower for electricity supply, affecting the powering of key institutions such as hospitals and health centres. Responding to climate change must be a global priority, especially given the accumulating evidence of more frequent and intense weather events endangering people's lives and livelihoods worldwide. Climate change urgency, combined with the world's growing appetite for energy, is driving nations to seek an energy mix that simultaneously reduces greenhouse gas emissions, improves health, protects biodiversity and the environment, enables economic growth, creates jobs, resilience, and socioeconomic prosperity, and ensures no one falls behind. Because energy use accounts for around two-thirds of worldwide anthropogenic emissions, decarbonization of the energy sector is central to the climate action agenda. The necessity to reduce CO2 emissions from energy is a major motivator for energy transitions. As a result, immediate action is required to align energy patterns with the Paris Agreement equivalent pathway. Energy transitions can take different shapes, depending on local circumstances, endowments, and starting places.

SDG 7 defines some of the key elements of the required energy transition, such as universal access, significant increases in renewable energy in the global mix, and doubling energy efficiency, and these actions represent an opportunity to deliver on climate action

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while also contributing to the achievement of multiple SDGs. Renewable energy solutions and energy efficiency measures, according to the International Renewable Energy Agency (IRENA), have the potential to achieve 90% of the energy-related carbon reductions required by 2050 by IPCC recommendations, while ensuring clean energy access for all (IRENA, 2021). However, decarbonization of the energy sector necessitates immediate global action, as well as alignment with the Paris Agreement and the 2030 Agenda, to ensure that this transition is just and leaves no one behind. Investing in the energy transition will also offer long-term benefits, such as job creation, increased GDP, decreased air pollution, and improved health, as well as helping to phase out coal, achieve universal access for everyone, and ensure a just and resilient transition. According to IRENA, an energy transition based on significant increases in renewable energy power generation, electrification of end-use sectors, and energy efficiency improvements would have long-term consequences. To accomplish SDG 7, funding for expanding access to contemporary types of energy, particularly clean cooking, must be increased. Electrification and clean cooking investments should be increased to become a major component of the global recovery package. The socioeconomic advantages of reliable, sustainable, and inexpensive energy access are significant, and they support a just and inclusive recovery process while contributing to many SDGs.

The main emphasis on sustainable development and energy development is the idea of sustainable development goals (SDGs). The SDGs took the role of the MDGs, which were the predecessor to a worldwide initiative to end poverty in 2000. The MDGs did not consider other factors, such as climate change. The SDGs' objective and broader reach set them apart from the MDGs. MDGs and SDGs are depicted in Figure 3. Making the switch from MDGs to SDGs implementation of the 2030 Agenda for Sustainable Development. Sustainable Development Goals (SDG) were established at the 2012 United Nations Conference on Sustainable Development. 2002's World Summit on Sustainable Development (WSSD), which took place in Johannesburg, South Africa, was hosted in Brazil-Rio de Janeiro. Millennium Declaration of 2000 and its Millennium Development Goals (MDGs). The 122 countries that ratified the Kyoto Protocol 1992

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Framework on Climate Change from the United Nations Conference on Environment and Development, Rio Declaration, and Agenda 2021, 1988 UNEP and the World Metrological Organization (WMO) established the Intergovernmental Panel on Climate Change (IPCC). 1987 World Commission on Environment and Development's Our Common Future Report. The discourse has advanced to its maximum point as at 2021 (De Jong & Vijge, 2021).

The SDGs 7: Affordably priced and clean energy, SDG 11: Industry, innovation, and infrastructure, and SDG 13: Climate action were the main subjects of the review. The latter three are interconnected to produce a product with less carbon dioxide, either by using energy and resource efficiency approaches through the production process and usage of renewable energies (SDG 7) or by implementing technology with fewer emissions (SDG 9), with the overall goal being to reduce carbon dioxide emissions resulting from effective climate change action overall (SDG 13).

The energy intensity level of primary energy is the ratio of energy supply to GDP assessed at purchasing power parity. Energy intensity measures how much energy is required to produce one unit of economic output. A lower ratio means that less energy is required to produce one unit of output. Following an upward trend from 2010 to 2015, the rates of improvement in global primary energy intensity - that is, total energy supply per unit of gross domestic product (GDP)- have steadily slowed. In 2018, worldwide primary energy intensity was 4.75 megajoules (MJ) per US dollar (2017 PPP purchasing power parity), representing a 1.1% increase over 2017 according to the Policy Briefs in support of the High-Level Political Forum report. Between 2010 and 2018, the annual average rate of improvement in primary energy intensity in Eastern Asia and South-Eastern Asia was 3.1%. Between 2010 and 2018, the average yearly improvement rate in Central Asia, Southern Asia, and Oceania was 2.6%, exceeding the global average of 2%. Northern America and Europe had rates of improvement that were just below the world average (1.9%), whereas Western Asia, Northern Africa, Latin America, the Caribbean (0.8%), and Sub-Saharan Africa (1.4%) had the lowest rates of progress. Achieving SDG 7.3 (doubling the worldwide pace of energy intensity improvement by 2030) is critical since it supports the other SDG 7 targets. Global primary energy intensity increased at a 2% yearly pace

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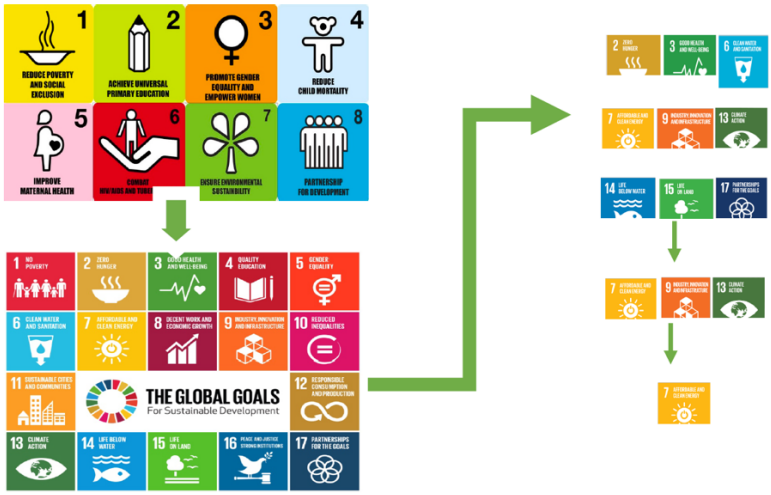
between 2010 and 2018. Although this was higher than the 1.2% rate between 1990 and 2010, it was still considerably below the 2.65% target set by SDG 7.3. To fulfil the aim stated in SDG 7.3, annual improvements must now average 3% through 2030. However, taking into consideration current and future regulations, as well as the COVID-19 issue, yearly efficiency gain is predicted to be only 2% between 2018 and 2030. The IEA's Sustainable Development Scenario, on the other hand, predicts that a combination of well-implemented policies and regulations may result in an annual average rate of 3.4% improvement in energy intensity between 2018 and 2030. Recent gaps in energy intensity improvements, below the rate required to fulfil the SDG 7.3 objective, would necessitate enhanced government initiatives. Making energy efficiency a priority in policy and investment in the coming years can assist the globe in meeting SDG 7.3, improving economic development, and ensuring universal access to clean, efficient energy.

Figure 43: *SDG Target 7.3 and Sustainability Program (UN, SDG 2023).*



Decades of global experience show that well-designed and implemented energy efficiency initiatives can provide benefits other than energy and emissions savings. Minimum Energy Performance Standards (MEPS), for example, are a tried-and-true policy tool. MEPS is one way to broaden obligatory policies and encompass more items in more sectors

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internationally. In many countries, government initiatives to lower the cost of energy-efficient equipment or building retrofits, including economic incentives such as grants or loans, have proven effective. Digitalisation is another developing trend that propels progress toward greater energy efficiency. Adopting large-scale data collecting, analysis, and digitalization techniques can aid in improving energy efficiency and leveraging flexibility options at the system level.

Despite global renewable energy investment reaching a record high of USD 434 billion in 2021, Africa received only 0.6% of the investment, an 11-year low, while between 2010 and 2020. South Africa attracted 85% of the region's renewable energy investment through its Renewable Energy Independent Power Producer Procurement Programme. In 2020, the country represented 57% of Africa's installed solar power capacity, with 5.9 GW (IRENA/AfDB, 2022). This suggests that, despite high investor interest in the worldwide clean energy transition, money and investment are not yet reaching the most vulnerable areas. In the past, the region had drawn only 2% of worldwide renewable energy investments.

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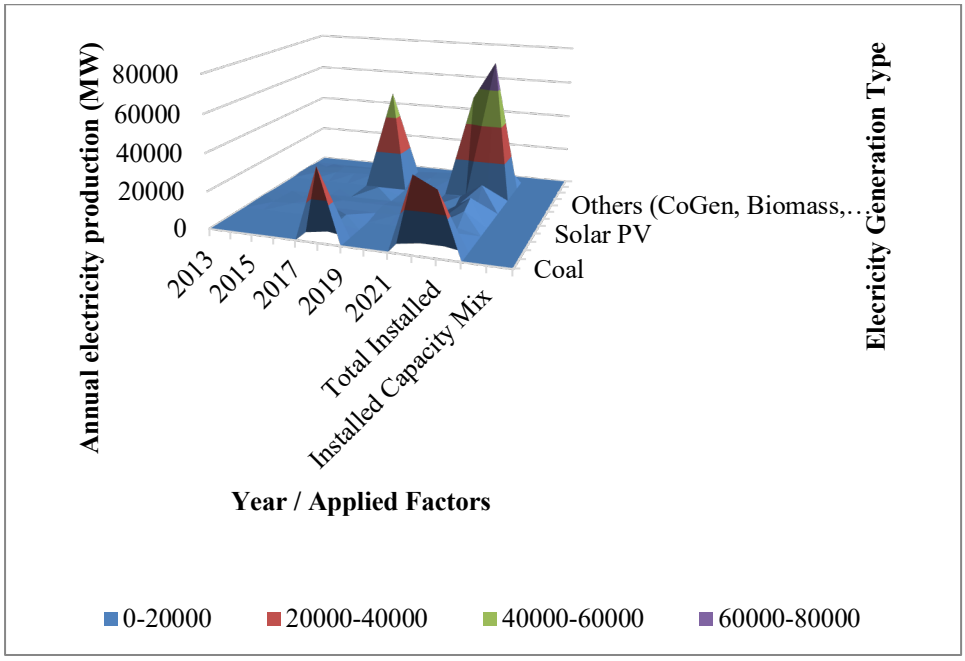
Figure 44: *Annual electricity production between 2013 and 2022, average capacity factors and the electricity generation type.*



In 2022, coal fell below 80% of total system load for the first time, while PV, wind, and CSP contributed 7%. In RSA, 3 443 MW of wind, 2 287 MW of large-scale solar PV, and 500 MW of CSP became operational between 2013 and 2022. South Africa generated 16 TWh of wind, solar PV, and CSP electricity in 2022; nevertheless, this was the first year in which solar output fell. The average annual capacity factor of the solar PV, wind, and CSP fleets in 2022 was 22.48%, 33%, and 29.70%, respectively in the last ten years. Peak annual consumption in 2022 is expected to be somewhat lower for more than a decade, while annual peak demand has been gradually dropping. Figure 5 provides information on the annual electricity production between 2013 and 2022, average capacity factors and the electricity generation type. South Africa is leading regional renewable energy investments, but the country's inefficient coal-based electricity system continues to affect the most disadvantaged. Between 2012 and 2021, the renewable energy proportion of total power capacity in Southern Africa increased from 14.7% to 28.6%, exceeding Africa's

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average (23%). Southern Africa was the primary receiver of renewable energy investment in Africa, accounting for more than 40% (USD 22.4 billion) of overall flows between 2010 and 20. Solar energy projects accounted for 60% of the investment (USD 13.5 billion), while wind energy projects accounted for 35% (USD 7.8 billion) (Bhargav, Gumbi & Winning, 2023; De Jonghe, 2022).

Building capacity for demand response initiatives in energy savings to promote a culture of better resource efficiency is part of the energy market (Oh & Chu, 2021). Numerous energy predictions have been studied with high accuracy by analysing a vast quantity of historical and sensing data. Since real-time data performance is necessary for Artificial Intelligence- Institute of Technology (AI-IoT) energy management systems and energy economy, most of these studies are not applicable in practice (Zou et.al., 2017). Energy efficiency has seen a significant increase in research interest recently, which is essential to change how energy is used (Tajudeen et.al., 2018). If the energy productivity demand across the economy improves through lean energy efficiency opportunities in manufacturing operations and the fourth industrial revolution, energy-intensive sectors such as industry, renewables, vehicles, buildings, and grids systems could provide a competitive advantage on a global scale and could gain cost advantage against global competitors (Adenuga et.al., 2017). Understanding various customers' energy needs and having the capacity to meet those needs while maintaining economies of scale are prerequisites for energy-efficient electricity distribution systems. These can be accomplished by breaking down the grid systems into different sectors, concentrating on the high-intensity energy consumers, and then progressively focusing on the others. By investigating the plan, the desire to create a patent for energy-efficient solutions to fight climate change and realise carbon emission reduction goals will be greatly realised.

Conclusion

The world has been marked by strong and severe economic, energy, and climatic crises, the repercussions of which are still being felt across countries and areas. As a result, in many regions of the world, human development and prosperity have been put on pause,

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if not reversed. It has also highlighted concerns about future paths in the sustainability, decarbonization, and net-zero agendas, as short-term responses to day-to-day difficulties have become a more pressing concern for individuals, businesses, and governments. To understand how this might play out further and what it implies for Africa's just energy development, this paper examines the Republic of South Africa energy, economic, and climate landscape as it stands today before reviewing its implications for country's socioeconomic and energy realities in the last 10 years.

The primary energy intensity level is defined as the ratio of energy supply to GDP at purchasing power parity. The amount of energy required to produce one unit of economic output is measured as energy intensity. A lower ratio indicates that less energy is needed to generate one unit of output. From 2010 to 2015, the rates of progress in global primary energy intensity - that is, total energy supply per unit of gross domestic product (GDP) - increased. In RSA, 3 443 MW of wind, 2 287 MW of large-scale solar PV, and 500 MW of CSP became operational between 2013 and 2022. South Africa generated 16 TWh of wind, solar PV, and CSP electricity in 2022; nevertheless, this was the first year in which solar output fell. The average annual capacity factor of the solar PV, wind, and CSP fleets in 2022 was 22.48%, 33%, and 29.70%, respectively in the last 10 years.

Furthermore, the examination of the Specific Catch-Up Performance Index (SCUPI) within the energy sector reveals that while this sector has a significant contribution to economic growth because all other sector depends on this one for energy supply. While the increase in SCUPI in 2014 is commendable, there remains potential for further acceleration in closing the income gap. Policymakers are therefore encouraged to prioritize this sector as it is a foundation for any economic growth that the country could realize with the constant supply of energy.

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