NATURAL RESOURCES, PRODUCTIVE CAPABILITIES AND ECONOMIC PERFORMANCE ACROSS SUB-SAHARAN COUNTRIES: ECONOMIC COMPLEXITY AND PRODUCT SPACE PERSPECTIVES

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ABSTRACT

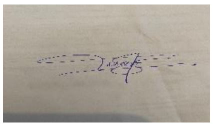
In the wake of two decades referred to as ‘growth tragedy’, sub-Saharan countries entered a phase of remarkable growth acceleration starting from the mid-1990s. Despite this, sustaining rapid growth proved elusive for many, with only a handful of resource-poor nations maintaining a consistent rapid growth trajectory by the end of 2019. This study delves into the mixed outcomes suggested by empirical research on resource curse theory, critically analysing the literature on the impact of natural resources on growth. Standard empirical growth models used in this literature often overlook the heterogenous nature of economies, particularly the complexity of knowledge and capabilities embedded in countries’ productive structures. This PhD study aims to unravel the hidden growth potential and dynamics of both resource-rich and resource-poor sub-Saharan countries. Building on the capability theory of growth as a foundation, we adopt an evolutionary perspective to economics and use an extended growth regression framework that acknowledges the potential role of natural resources and country’s productive structure in growth modelling. This framework allows for a comprehensive examination of the presence or not of resource curse and other potential capability-based traps to development. Additionally, we rely on non-parametric methods, leveraging complex network theory and machine-learning techniques underpinning the economic complexity and relatedness approaches. Our findings reveal that the main obstacle to sustained growth in sub-Saharan economies is not their dependence on natural resources, but rather the limited incentives to accumulate and develop productive capabilities – “a quiescence trap”. Furthermore, resource-rich countries often possess narrow and less complex endowment of capabilities, which constrains their growth potential and leads to erratic growth patterns. These countries also face challenges in transforming their productive structures and diversifying into high value-added sectors associated with strong productivity dynamism. Our study underscores complex capabilities as a crucial element for sustaining growth in sub-Saharan Africa. It advocates a policy shift from an excessive focus on maintaining ‘sound macro fundamentals’ to prioritizing the nurturing of productive capabilities at the firm, industry, and country levels through targeted industrial and innovation policies.

RESUME

À la suite de deux décennies qualifiées de ‘tragédie de la croissance’, les pays de l’Afrique subsaharienne ont connu une phase d'accélération de la croissance remarquable à partir du milieu des années 1990. Malgré cela, maintenir une croissance rapide s'est avéré difficile pour beaucoup, avec seulement quelques pays pauvres en ressources naturelles réussissant à maintenir une trajectoire de croissance rapide jusque à la fin de 2019. Cette étude explore les résultats mitigés suggérés par la recherche empirique sur la théorie de la malédiction des ressources naturelles, en analysant de manière critique la littérature sur l'impact de l’abondance/dépendance aux ressources naturelles sur la croissance. Les modèles empiriques standard utilisés dans cette littérature négligent souvent la nature hétérogène des économies, en particulier la complexité des connaissances et des capabilités intégrées dans les structures productives des pays. Cette étude de doctorat vise à identifier le potentiel caché et le dynamisme de croissance des pays subsahariens riches et pauvres en ressources naturelles. S’appuyant sur la théorie des capabilités de la croissance comme fondement, nous adoptons une approche évolutionniste de l’économie et élargissons le cadre empirique de la croissance en reconnaissance du rôle potentiel des ressources naturelles et de la structure productive des pays dans la modélisation de la croissance. Cette approche permet un examen complet de la présence ou non du phénomène de malédiction des ressources naturelles et d’autres types de stagnation du développement basés sur les capabilités. De plus, nous nous appuyons sur des méthodes non paramétriques, en tirant parti de la théorie des réseaux complexes et des techniques d’apprentissage automatique qui sous-tendent l’approche de complexité économique. Nos résultats révèlent que le principal obstacle à une croissance rapide soutenue dans les économies subsahariennes n'est pas leur dépendance aux ressources naturelles, mais plutôt les incitations limitées à accumuler et à développer des capabilités productives – un piège de stagnation. En outre, les pays riches en ressources naturelles possèdent souvent un ensemble de capabilités étroit et moins complexe, ce qui limite leur potentiel de croissance et conduit à des trajectoires de croissance erratiques. Ces pays rencontrent également des difficultés à transformer leurs structures productives et à se diversifier vers des secteurs à forte valeur ajoutée associés à un fort dynamisme de la productivité. Cette étude souligne que des capabilités complexes constituent un élément crucial pour soutenir une croissance rapide en Afrique subsaharienne. Elle plaide pour un changement de politique, passant d'une focalisation excessive sur les ‘fondamentaux macroéconomiques solides’ à la priorité accordée au développement des capabilités productives au niveau des entreprises, des industries et du pays, à travers des politiques industrielle et d’ innovation ciblées.

DECLARATION

I, ***Luabeya Franck Kapiamba***, student identification number 2285647, declare that this PhD thesis titled "*Natural Resources, productive Capabilities and Economic Performance across Sub-Saharan Countries: Economic Complexity and Product Space Perspectives*" is my own research work. Articles and materials, representing the works of others, used for this research have been duly referenced and acknowledged. This research work has not been presented before for examination leading to an award of any degree either to this university or any other.



LUABEYA Franck KAPIAMBA (2285647)

Date: 24/10/2024

DEDICATION

This PhD thesis represents a culmination of countless hours of work, late nights and moments of self-doubt. It is a testament to perseverance and power of faith in God's plan for every man and woman. I dedicate it to:

- My late father, **Anatole Kapiamba**, who planted the seed of knowledge in my mind, gave me the gift of dreams and the ability to realise them.
- My mother, **Yombo Kalala Anasthasie**, for being the woman who first held me in her wombs and endured invaluable sacrifices to support my education.
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- To my sons, **Sharon Luabeya** and **Mike Luabeya**, whom I dearly hold in my heart. The pursuit of my academic dream has cost them to miss my loving touch during the best years of their childhood. I wish I could take the time back and play football with them. I ask them to please forgive me for my absence during those precious years. May they find inspiration in my perseverance and trust in the Lord Jesus Christ, our Living Hope of glory. Never give up God-given dream no matter what comes in your way.
- My late uncles, **Léonard Kalombo** and **Grégoire Tshiunza**, for being my stars and helping me in the turbulent rise to reach the sky.
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ABREVIATIONS

ACET: African Centre for Economic Transformation

AfDB: African Development Bank

BACI : Base pour l'Analyse du Commerce International

CA: Capabilities Accumulation

CEPII : Centre d'Etudes Prospectives et d'Informations Internationales

COG: Complexity Outlook Gain

COI : Complexity Outlook Index

EC: Economic Complexity

ECI: Economic Complexity Index

EDI: Economic Diversity Index

EF: Economic Fitness

EFC: Economic Fitness and Complexity

FMOLS: Feasible Modified Ordinary Least Squares

GDP: Gross Domestic Product

GGDC: Groningen Growth Development Centre

GMM: Generalized Method of Moments

HS: Harmonized System (of commodity trade classification)

IMF: International Monetary Fund

MIC: Middle Income Country

MR: Method of Reflections

OECD: Organisation for Economic Cooperation and Development

OLS: Ordinary Least Squares

PCI: Product Complexity Index

PMG: Pooled Mean Group (estimation method)

PPN: Product Progression Network

RCA: Revealed Comparative Advan

SITC: Standard International Trade Classification

SPS: Selective Predictability Scheme

SSA: Sub-Saharan Africa

TFP: Total Factor Productivity

TNRR: Total Natural Resource Rents

UNCOMTRADE: United Nations Commodity Trade Statistics Database

UNDP: United Nations Development Programme

UNECA: United Nations Economic Commission for Africa

UNIDO: United Nations Industrial Development Organisation

CHAPTER 1

INTRODUCTION

1.1. BACKGROUND OF THE STUDY

For decades, governments in developing countries have been eagerly pursuing the objective of sustaining rapid and inclusive economic growth to drive progress, create decent jobs for all and improve living standards. Unfortunately, achieving this policy goal remains a dauting challenge for many countries, especially in Sub-Saharan Africa (henceforth SSA, region, subcontinent). As the literature on growth turning points has described it, modern growth exhibits patterns of hills, plateaus, mountains, and plains, with most developing countries alternating between episodes of fast growth and episodes of stagnation or decline (Pritchett, 2000). Scholarship under this strand of literature has established that experiences of economic growth acceleration are fairly frequent across countries in the world, including in Africa (Arizala et al. 2017; Hausmann, Pritchett, & Rodrik, 2005; Toh, 2016); it has also highlighted that sustaining fast growth rates remains an elusive policy priority for many developing countries.

As suggested by historical evidence from the experience of developing countries over the last decades since the 1950s, very few economies have successfully sustained rapid growth rates over periods of several decades. Rodrik (2014) reports that since 1950, there had been only 24 distinct instances of "growth miracle", defined as "real per capita income growth of at least 4.5% sustained over at least 3 decades" (p.24). Three of these instances were recorded in SSA: Botswana (7.3 % :1960-91), Equatorial Guinea (9.3 %: 1974-2004) and Cabo Verde (5.5 %: 1977-2007). Similarly, Hausmann, Pritchett, and Rodrik (2005)[1] consider episodes of per capita growth acceleration that are maintained for at least eight years and identify eighty-three such episodes since the 1950s. Only eighteen of these sustained growth accelerations occurred

[1] These scholars define a growth acceleration as "an increase in per-capita growth of 2 percentage points or more. To qualify as an acceleration, the increase in growth must be sustained for at least eight years and the post-acceleration GDP per capita growth rate must be at least 3.5 percent per year." In addition, to rule out cases of pure recovery, they require that "post-acceleration output exceed the pre-episode peak level of income" (p. 304).

in Africa. This is surprising in view of the enormous share of natural capital in SSA's wealth (Izvorski, 2018; The World Bank, 2021).

The growth experience of SSA is marked by high-frequency growth turning points (up-breaks and down-breaks) and growth accelerations (growth spells) since the 1960s (Arbache, Go, & Page; 2008; Arizala et al., 2017; Gill & Karakulah, 2019; Ndulu et al., 2007; Raddatz, 2008). With their large swings and hard landings, these patterns of growth have left painful human scars in the sub-continent. These growth turning points reflect a series of shocks that have plagued the region, including wars, political instability, natural disasters, epidemics, terms-of-trade deterioration, and sudden stops in capital inflows, among others. These shocks have had protracted effects on the factors of production (physical capital and human capital) as well as on total factor productivity (TFP) because of structural characteristics of SSA' economies that compound the impact of those shocks (Calderon, 2022).

Easterly and Levine (1997) called a "tragedy" the Africa's economic history of "unfulfilled potential" since 1960. These scholars report that in 1960 Africa was ranked ahead of East Asia in terms of their growth potential, with at least seven African countries identified as having the potential to reach or surpass a 7 percent growth rate. Yet, by 1990, these hopes remained unfulfilled. On average, real per capita GDP was sluggish in Africa over the period 1965-1990 with most countries even experiencing negative growth, while per capita GDP of Latin America and East Asia & the Pacific grew by an annual average rate of over 2 and 5 percent, respectively. Even more disappointingly, the seven African countries listed as having high growth potential by the World Bank were among those with negative growth. Easterly and Levine's tune on growth in Africa is echoed by the Editor of a respected magazine, the Economist (May 13, 2000), who called Africa "the hopeless continent", thus reverberating narratives which refer to Africa as a "basket case".

However, in the mid-1990s, after stagnating for two consecutive decades, Africa finally turned the corner. For two decades until 2014, many countries in SSA experienced unprecedented growth acceleration, making the first couple of decades in the 21st century a remarkable period of fast economic convergence (Diao, McMillan, & Rodrik, 2019). SSA even experienced "positive total factor productivity growth for the first time since the early 1970s" (Rodrick, 2018, p.10) and was the fastest-growing region. From 1996 to 2014, growth of real GDP in SSA sharply accelerated from 1.4 percent in 1978–95 to an annual average rate of 4.8 per cent.

SSA grew faster than East Asia in 13 of the 19 years from 1996 through 2014 (Calderon, 2022). According to a report by the International Monetary Fund (IMF, 2013), six of the World's ten fastest growing countries in the 2000s were in SSA; these include Angola (11.1%), Nigeria (8.9%), Ethiopia (8.4%), Chad (7.9), Mozambique (7.9%), and Rwanda (7.6%). Several other SSA countries also recorded a growth rate above or near 7%, implying that these countries could double their economies in 10 years or by 2022.

Scholars celebrated SSA's recent growth performance with rosy publications as a take-off to a growth miracle and the end of the so-called natural resource curse. Most notable among these are: "Africa's growth turnaround: from fewer mistakes to sustained growth"(Page, 2009); "Lion on the Move" (McKinsey Global Institute, 2010); "Africa rising: How 900 million African consumers offer more than you think" (Mahajan, 2011); "African Growth Miracle"(Young, 2012); "What is driving African growth miracle?"(McMillan & Harttgen, 2014). SSA's growth performance was so unusually good that The Economist made a U-turn, changing its narrative from regrettably calling Africa "the hopeless continent" to "Africa's Rising" (December 3, 2013). To illustrate the rise of Africa, this magazine even used on its front cover a portrayal of a boy flying a rainbow-colored kite in the shape of the continent.

However, sustaining the fast growth rates proved evanescent for many countries in SSA, particularly for resource-rich economies. According to the IMF Regional Economic Outlook for sub-Saharan Africa, by the end of 2019, "some 21 countries, mainly the region's more diversified economies, were expected to sustain growth at 5 percent or more and remain on the impressive per capita convergence path they have been on since the early 2000s" (IMF, 2019, p.1). Growth decelerated in the remaining 24 SSA economies, comprising mostly natural resource-rich countries (See Appendix A: Sub-Saharan resource-rich and resource-poor countries), where "growth looked set to remain anaemic in the near term" (p.1).

The historically heterogeneous long-term growth patterns between SSA and the rest of the developing world, combined with the ongoing growth spells that are sustained in some sub-Saharan resource-poor economies for little over two decades, raise challenging questions. Policymakers, business leaders, as well as ordinary people are seeking answers to the following questions: Why do sub-Saharan countries more than often fail to sustain growth accelerations relative to their counterpart in developing world? What accounts for the success of sub-Saharan resource-poor economies that remain on a sustained growth spell since the early 2000s? Are there inherent structural differences between resource-poor and resource-rich economies? What lessons can policymakers learn from “emerging” SSA’s resource-poor countries to break the curse of frequent growth “up-breaks” and “down-breaks”? These questions and more others are important given the staggering consequences of poor economic growth on human welfare, political stability, and peace in sub-Saharan countries. Identifying factors which allow to distinguish between countries that succeed to sustain growth spells and those that fail to do so is of paramount importance for designing effective economic growth policies aimed at sustaining rapid growth – a precondition for creating decent jobs, reducing poverty and catching up with the income levels of developed nations.

For decades, scholars have investigated the sources of SSA’s poor economic growth performance and linked it to several overlapping factors. Most notable papers in the mainstream economics point to the natural resource curse (Sachs & Warmer, 1995), poor economic policies (Sachs & Warmer, 1997), ethnic diversity and conflict (Easterly & Levine, 1997), colonial extractive institutions (Acemoglu, Johnson, & Robinson, 2001; Robinson & Acemoglu, 2012),), adverse geographical and climate factors (Sachs, 2012) and other critical debilitating deficits (Gill & Karakulah, 2019). Sachs (2012) even emphasises that “Africa's slow growth can be explained according to the same variables that account well for the growth performance of other parts of the developing world. There is no need for a special 'Africa' theory, at least about proximate causes of economic growth” (pp.335-336).

The strand of literature on growth turning points, which emerged owing to the work of Pritchett (2000), “recognizes that cross-country differences in per-capita income are more closely related to differences in the volatility of growth and less to structural differences in the levels of growth rates” (Arizala et al;, 2017, p.1). This literature distinguishes factors that are associated with growth accelerations from those that account for the duration of growth accelerations (e.g., Arizala et al., 2017; Hausmann, Rodriguez, & Wagner, 2006; Kerekes, 2012; Mora & Siotis, 2005; Ostry & Zettelmeyer, 2012; Tsangarides, 2012). In the context of Africa particularly, Tsangarides (2012) found that the factors associated with the duration of growth acceleration in SSA differ from those in the rest of countries in the world, highlighting the role of trade openness and droughts. In similar vein, Arizala et al. (2017) present findings which suggest that growth accelerations in SSA are sustained by better macroeconomic policies, reduced debt-to GDP ratios, more outward-oriented trade policies, higher investment-to-GDP ratios, improved macro-structural policies captured by smaller market distortions and better-quality institutions. Despite its appealing approach which emphasises variations in growth rates within countries over time, the growth turning points literature remains in the tradition of mainstream economics which focuses on key determinants of growth as theorised in neoclassical growth models.

Following the unprecedented growth acceleration in SSA from the mid-1990 and the seminal contributions by Herrendorf et al. (2014) and Duarte and Restuccia (2010), who find that structural transformation is the main feature of modern economic growth, scholars have focused attention on structural change as a potential engine of growth in Africa. Overall, they unanimously find that, whereas structural transformation played a growth-reducing role in SSA countries before the 2000s, recent growth acceleration in the sub-continent has been positively associated with substantive structural transformation (de Vries et al. 2015; Diao, McMillan & Rodrik, 2019; Diao et ai.2017; McMillan & Harttgen, 2014; McMillan, Rodrik & Verduzco-Gallo, 2014; McMillan & Rodrik, 2011). Turning to the prospects for sustained growth in SSA, scholars raise concerns about the patterns of structural transformation in the region, which suggest that countries in this region are bypassing industrialisation, with increasing share of employment in low-productivity informal service sector and a decline in labour productivity in modern sectors such as manufacturing industries (Diao, Ellis et al., 2021; Diao, McMillan & Rodrik, 2019: Diao et al. 2017, McMillan & Zeufack, 2022; MacMillan & Rodrik, 2015; Rodrik, 2016). As a result of an increasing share of labour working in low-productivity sectors, such as agriculture and informal service, SSA lags other world's regions in structural transformation (Duarte & Restuccia, 2018).

In the recent years following the growth deceleration in SSA, there has been an increasing focus on productivity in the region. This reflects lessons from growth accounting studies which show that improvement in productivity is essential to sustained growth (Kim & Loayza, 2019). In a volume comprising a range of contributions focusing on SSA as part of the World Bank's Productivity Research Agenda, Calderon (2022) highlights the persistence of the productivity gap in Africa vis-à-vis the technological frontier. Overall, the findings from this research report show that labour productivity in SSA has lagged far behind the United States and the EAP5 countries (Indonesia, South Korea, Malaysia, Singapore, and Thailand), which are used as the global efficiency benchmark and aspirational development benchmark, respectively. The report attributes SSA's decline in productivity to two important factors: (i) the slow accumulation of physical and human capital resulting from multiple shocks that have historically plagued the region: (ii) the allocative inefficiencies of these resources, as a result of distortions introduced by policies and institutions in the decision-making process of individuals and firms.

Against this research background on growth in SSA, the neglect of the data quality debate in growth research is glaring in Africa, with some scholars even frontally arguing over whether economists got it wrong in Africa (Alenda, 2022; Jerven,2015; Obeng-Odoom, 2017). Pointing to the titles on the front pages of The Economist magazine - “The Hopeless Continent” (2000) and “The hopeful continent: Africa Rising” (2011) - Jerven wonders whether the editors of The Economist have a character flaw that makes them incapable of consistent judgment. He demonstrates concretely that economists are entirely mistaken in their analyses of what is happening in Africa. “Not only is their statistical information contrived, but also their description is wrong, their explanation is worse, and their policy advice is grotesquely awry” (Obeng-Odoom, 2017, p.466. citing Jerven, 2015). These scholars call for a greater attention to what they see as “the tragedy of data” in African countries and “wrong growth economics” underpinned by models in economics that were formulated based on experiences outside the African continent.

Notwithstanding these controversies, policy advice in SSA resource-rich countries over the last three decades has been driven by the research findings on resource curse theory, which has by far attracted the attention of economists and other social scientists since the seminal paper by Sachs and Warner (1995). This research often uses the growth tragedy of sub-Saharan resource-rich economies[2] as an illustration of the resource curse manifestation. However, despite intense research and flourishing literature, there is no consensus as to whether natural resources are a curse or a blessing for the countries that possess them in abundance or depend on them. Literature survey studies, which critically discuss various theoretical explanations for the resource curse alongside a survey of the empirical works, find that the evidence is mixed (Alssadek & Benhin, 2023; Badeeb et al., 2017; Frankel, 2012; Papyrakis, 2017; Rosser, 2006; Roy et al., 2013; Van Der Ploeg, 2011). The heterogeneity of the results is also confirmed in meta-analysis studies of empirical evidence on resource curse (see e.g. Dauvin & Guerreiro,

[2] According to Izvorski et al.(2018), the share of natural capital in Africa’s aggregate wealth is the second highest in the world after the countries that form the hydrocarbon-rich Gulf Cooperation Council (GCC). Even resource-poor SSA, with its relatively low level of natural capital per capita, has a share of natural capital in total wealth that is higher than resource-rich MICs outside Africa”.

2017; Havranek et al., 2016; Sebri & Dachra, 2021; Zhang & Brouwer, 2020). These analyses suggest that various aspects of study design, sampling period, country grouping, and estimation methods explain the differences in results across studies, regions, and periods.

The practical implications of the resource curse research have dominated the thinking on economic growth policy design and implementation in SSA countries. More remarkably, they have led to a greater emphasis being put on conventional macroeconomic policies of neoclassical inspiration, with their excessive focus on developing long-term growth fundamentals and maintaining macro stability under the banner of ensuring "sound macro fundamentals" (Nissanke, 2018). Notwithstanding these policies, and as evidenced by a sheer number of papers focusing on Africa[3], the so called resource curse seems to persist even during the growth acceleration period that resource-rich countries experienced from the mid-1990s.

Following the World Bank's mea culpa regarding the economic growth policies spawned by the Washington Consensus in the 1990s (see Rodrik, 2006; Zagha & Nankani, 2005), scholars have pointed to the limits of the mainstream policies to accelerate and sustain growth. For example, Nissanke (2018) forcefully opined that " the conventional macroeconomic policy discourse is grossly inadequate in accelerating the pace of structural transformation, or even triggering the transformation process in its earnest" (p.2). Similarly, Rodrik (2018) underscores the ambiguity of the growth effect of improvements in the policy and institutional environment, noting that while such improvement can be expected to generate greater economic stability and prevent deep crises arising out of mismanagement, " it is not clear that it provides a significant boost for economic growth, and nor that it acts, on its own, as the engine for a growth miracle" (p.). These scholars echoed the findings from early empirical studies in the growth turning points literature, which suggest that the standard neoclassical growth determinants do not robustly explain rapid acceleration in economic growth (Hausmann, Pritchett, Rodrik, 2005).

The excessive focus on conventional macroeconomic policies, structural and institutional reforms has also meant that little attention had been paid to the industrial and innovation policies aimed at upgrading technological capabilities, which are found to be the corner stone

[33] Alssadek & Benhin (2023) conduct a survey of literature on resource curse and provide a summary of findings from empirical studies published in the leading journals on the subject. We identify 10 empirical studies focusing on Africa during the period from ……to 2022. Nine of these studies confirm the presence of the resource curse.

of rapid sustained growth in East Asian countries (Lee et al. 2021, Mohnen & Hall, 2013, Nelson & Winter, 1982; Paus, 2017). Scholars and organisations have pointed out that the process of productive capability upgrading has failed or remains ineffective in many developing countries, particularly SSA, due to underinvestment in innovation activities, a lack of complementary investments, and market failures (Lee et al. 202; Cicera & Malony, 2017). This is consistent with the strand of literature referred to as "Schumpeterian technological catch-up and innovation", which focuses on the processes of capabilities accumulation and upgrading and has shown that the patterns and rates of long-term economic growth are strongly driven by technological upgrading and innovation (Abramovitz, 1986; Lall, 1992; Lee. 2019; Lee et all., 2021; Sutton, 2012).

In the late 2000s a new strand of literature referred to as "economic complexity"(EC) emerged in macroeconomics of development, with a novel conceptual view of growth and development. Drawing on insights from neoclassical endogenous growth models and building on the concept of capabilities central to the evolutionary economics, strategic management and innovation literature, Hidalgo et al. (2007) and Hidalgo and Hausmann (2009) made seminal contributions, conceptualising economic development as a process of learning how to produce (and export) more complex products that are associated with higher value-added and productivity. Leveraging on network theory methods, these scholars show that the development path of a country is determined by its capacity to accumulate the capabilities that are required to produce varied and more sophisticated goods. Following these groundbreaking contributions, several papers have provided overwhelming empirical evidence suggesting that the overall complexity of a country's productive structure is harbinger of growth, a key determinant in explaining cross-country growth differences. In other words, countries' different abilities to accumulate capabilities explain differences in their performance (Tacchella et al., 2012; Cristelli et al., 2013; Hausmann et al., 2014; Cristelli, Tacchella & Pietronero, 2015; Cristelli, Tacchella, Cader et al., 2017; Sbardella, Pugliese eet al.,2018).

In the last decade, the EC approach has grown in popularity " as an innovative framework to analyse the process of economic growth from the perspective of network science and machine learning, which provide new data-driven algorithmic and theoretical tools to the study of social phenomena (Castañeda, Pietronero et al., 2022, p. 231). These scholars underscore that the EC approach can jointly investigate three sets of old ideas of the economic literature: (i) the competitiveness of countries in terms of their economic structures, including technological and industrial features[4]; (ii) the existence of organizational capabilities that are difficult to replicate by outsiders because they are developed in-house in a learning-by-doing process, and which allow firms to elaborate goods and services in different economic activities, stages in the production chain, and degrees of sophistication[5]; (iii) an evolutionary dynamic that explains how industries evolve in a Schumpeterian process of creative destruction[6]. The EC approach has been used by scholars to solve the puzzle about the fast growth sustained for over 3 consecutive decades by China and other Asian emerging economies.

Despite its increasing popularity, the EC approach has not been used to analyse medium- and long-term economic performance of sub-Saharan countries as a region. The present PhD thesis fills this research gap. Departing from the mainstream focus on natural resource curse, it draws on insights from the EC approach to investigate the existence of capability-based traps that may potentially explain the poor growth performance of SSA in general and the success of few resource-poor relative to resource-rich countries.

1.2. STATEMENT OF THE PROBLEM

In spite of the existence of significant sectoral productivity gaps that represent an enormous potential for sustained rapid growth, sub-Saharan's economies tend to have less complex and unchanging productive structures that are geared towards the production of goods and services in low value-added sectors. This constrains their potential for economic diversification, which is essential for productivity improvement and sustained economic growth performance.

Going beyond the mainstream 'growth fundamentals' approach which has dominated growth empirics research in SSA, the aim of this PhD thesis is to shed light on the factors underlying the dynamics of SSA countries 'economic performance. We focus on natural resources and productive capabilities emphasised by the economic complexity approach to growth and development, exploring the role these factors play in driving the underlying processes leading to economic growth. The purpose is to provide a strong evidence-based foundation for the

[4] Citing Rosenstein-Rodan, 1943; Prebisch, 1950; Myrdal, 1957; Hirschman, 1958; Furtado, 1964)
[5] Citing Penrose, 1959; Teece, 1982, 1997; Dosi et al., 2000, 2008.
[6] Citing Schumpeter, 1934; Aghion and Howitt, 1992; Carlsson and Eliasson, 2003; Saviotti and Pyka, 2004; Hanusch and Pyka, 2007.

design of policies and programmes to accelerate and sustain economic growth in SSA countries.

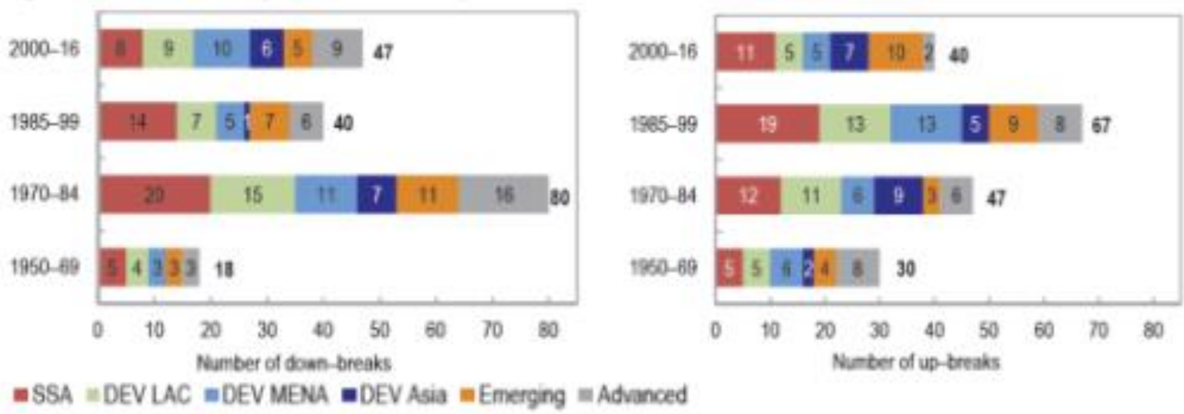
Several studies have emphasised the structural dualism of developing economies and documented the existence of significant sectoral productivity gaps in Africa (e.g., Diao et al., 2019; Gollin et al.2014; McMillan & Rodrik, 2011; McMillan, Rodrik, & Verduzco, 2014; McMillan & Headey, 2014; Mensah et al., 2023). While these scholars view the productivity gaps between and within sectors as indicative of the allocative inefficiencies that reduce overall labour productivity, they also point out that "the upside of these allocative inefficiencies is that they can potentially be an important engine of growth" (McMillan & Rodrik 2011, p.1). In the same vein, Temple (2005, p.195) underscores that, in developing economies where significant sectoral productivity gaps exit, "the 'growth bonus' obtained by reallocating labour to a sector where productivity is higher can represent a large share of economy-wide productivity growth".

Different sources document that sub-Saharan countries remain highly specialised in few commodity and resource-based manufacturing products (e.g., Harvard Growth Lab's Atlas of Economic Complexity; Observatory of Economic Complexity). According to the IMF's economic diversification index (EDI) for 2023, Africa hosts 13 of the world's 20 least diversified countries, which weakens the foundation of their economic transformation, slows their pace of progress and makes them particularly vulnerable to sudden external shocks (Prasad et al., 2024). These shocks have had deep-rooted negative impact on the productivity (level and growth) in the countries of the region. As a result, in terms of productivity, SSA is lagging far behind the United States and the EAP5 countries (Indonesia, South Korea, Malaysia, Singapore, and Thailand), which are the global efficiency frontier benchmark and aspirational development benchmark respectively (Calderon, 2022).

Evidence from the emerging literature on structural transformation in Africa suggests that while the share of agriculture in total employment and value added is declining, SSA is bypassing industrialisation. Resources are being moved into the service sectors that have been historically associated with lower productivity (Diao et al. 2019; Duarte & Restuccia, 2023; McMillan & Zeufake, 2022; Mensah et al., 2023). As in Rodrik (2018), these studies paint bleak prospects for sustained growth in SSA countries, due to what they view as the 'servicification' of the economies and premature industrialisation (Rodrik, 2016).

Historically, the lack of economic diversification in SSA, combined with the effects of multiple shocks to which the region is exposed, has left deep-rooted footprints in sub-Saharan countries, with high volatility and brevity of growth spells being the main feature of SSA’s long-term growth patterns (Arizala et al., 2017; Gill & Karakulah, 2019). This is illustrated in figure 1.1.

Figure 1.1. Selected Groups: Growth Up-Breaks, 1950–2016



Note: DEV Asia= developing Asia; DEV LAC = developing Latin America and the Caribbean; DEV MENA = developing Middle East and North Africa; SSA = Sub-Saharan Africa.

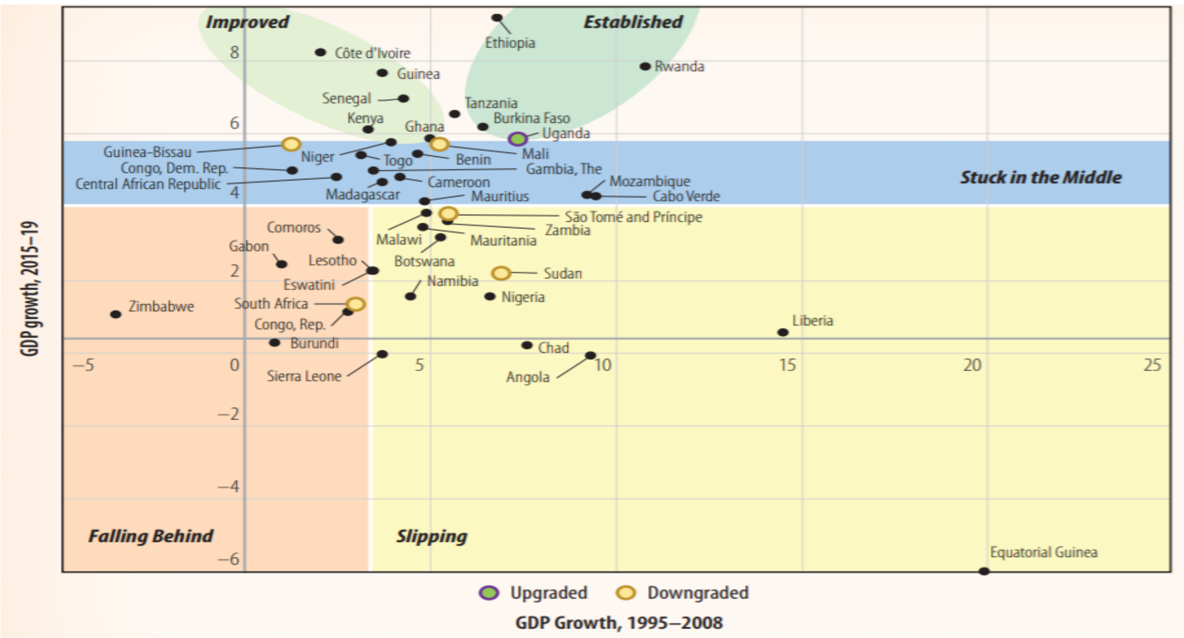
Source: IMF, Regional Economic Outlook: Sub-Saharan Africa–Restarting the Growth Engine, 2017 (April).

In figure 1.1. from the study commissioned by the IMF, Arizala and co-authors find that SSA experienced about 25 percent of up-breaks and down-breaks of the total growth turning points which occurred in developing economies over 1950–2016 period. Moreover, the study finds that countries in SSA tend to experience large growth swings between up-breaks and down-break, with the largest break size among all groups examined.

More importantly, the study finds that, while the region recorded about 30 percent of total growth spells identified over the sample period, “periods of growth acceleration in sub-Saharan countries have tended to be shorter, start from worse growth positions, and more often end in ‘hard landings’ compared to spells elsewhere” (p.5). The study stresses that this result is robust to controlling for armed and political conflicts, suggesting that SSA economies may be different from the rest of the economies in emerging and developing countries (here and thereafter “developing countries”) in terms of their growth potential and factors enabling sustained growth acceleration.

The consequences of limited economic diversification on growth resilience in SSA resource-rich economies are well documented in the World Bank Africa's Pulse biannual series since 2016. Following the 2014-15 collapse in commodity prices, growth decelerated suddenly in all resource-rich economies that had surprisingly experienced unprecedented faster growth than their counterpart's resource-poor from the mid-1990s (Irzoviski, 2018). Only few diversified resource-poor countries remain on the impressive per capita growth convergence path they have been on since the early 2000s (IMF, 2019). These countries have emerged either as "strong growth performers" (Burkina Faso, Ethiopia, Rwanda, Tanzania, and Uganda) or 'improved growth performers"(Côte d'ivoire, Ghana, Guinea, Kenya , and Senegal). These ten countries continued to have annual average growth rates in 2015-2019 that exceeded the top tercile of the regional growth distribution in 1995-2008 (see figure 1.2).

Figure 1.2: Taxonomy of growth in Sub-Saharan Africa (1995-2019)



Source: World Bank Africa Pulse, Vol. 20, October 2019. Notes: 'The growth taxonomy compares the average annual rate of GDP growth during 1995–2008 and 2015–19 against predetermined thresholds. These thresholds correspond to the 33rd and 67th percentiles of the annual average growth rate across 44 Sub-Saharan African countries during 1995–2008, which are 3.5 and 5.4 percent, respectively. Once the thresholds are established, the taxonomy classifies growth performance into five groups: (a) falling behind, (b) slipping, (c) stuck in the middle, (d) improved, and (e) established"(Calderon et al., 2019, p. 25).

According to Calderon et al. (2019), the number of countries in the bottom tercile of growth performers (falling behind or slipping)[7] had increased from seventeen in 2014-16 to twenty-one in 2019. "This group accounts for 42 percent of the region's population (437 million people in 2018) and produces 64 percent of the region's total GDP"(p. 25). Countries with decelerated economic performance in 2015-2019 relative to 1995-2008 represent about one-third of the

[7] Countries in this group (falling behind or slipping) include Angola, Botswana, Burundi, Chad, the Comoros, the Republic of Congo, Equatorial Guinea, Gabon, Lesotho, Liberia, Malawi, Mauritania, Namibia, Nigeria, São Tomé and Príncipe, Sierra Leone, South Africa, Sudan, Eswatini, Zambia, and Zimbabwe

region's population and 60 percent of its economic activity, including three largest economies- Angola, Nigeria, and South Africa.

If the figures provided in the World Bank's research report - "Boosting productivity in Sub-Saharan Africa" (Calderon, 2022) - are credible, the declining trend in labour productivity will continue to get worse in many SSA countries. From 1980 to 2017, about two-thirds of the region's countries (30 of 44) experienced a decline in the relative gross domestic product (GDP) per worker. Relative labour productivity in 2017 was less than half that of 1980 for nine countries in the region: the Central African Republic, the Comoros, the Democratic Republic of Congo, Guinea, Liberia, Niger, Nigeria, Togo, and Zimbabwe. The recurring growth breakdown and weak resilience in these countries imply a continued significant loss of incomes and hard-won gains made in social progress for two decades, increased unemployment, deterioration of living standards and mounting poverty for millions of households. There is a pressing need for research to understand what is holding back productivity growth in SSA and making it hard to sustain rapid growth.

The question of how to sustain growth in SSA has been traditionally addressed through the neoclassical-inspired macroeconomic lens, focusing on the accumulation of factors of production and more recently on the productivity growth. More remarkably, following the seminal contribution by Sachs and Warner (1995), scholars have focused their research on investigating the mechanisms through which natural resource abundance/dependence negatively affects growth directly or indirectly through its determinants (see surveys by Alssadek & Benhin, 2023; Badeeb et al., 2017). The policy implications of this research led to a greater focus on maintaining macroeconomic stability and ensuring sound growth fundamentals, such as physical capital, human capital, quality of institutions and governance. Both the IMF and the World Bank continue to focus on sound macroeconomic policy management, stressing that "there is a pressing need to complete the required fiscal and external account adjustments to lower commodity prices, for reforms to facilitate economic diversification and to promptly address the policy uncertainties that are holding back growth" (IMF, 2019, p. 1). These views find support in the scholarly literature on growth turning points, which provides empirical evidence suggesting that favourable factors, such as strong institutions, macroeconomic stability, improved macro-structural policies, outward-oriented trade policies, economic reform, etc. are statistically significant predictor of growth accelerations that are sustained (see e.g., Arizala et al., 2017; Berg, Ostry, & Zettelmeyer, 2012; Hausmann, Prichett, & Rodrik, 2005; Kerekes, 2012; Tsangarides, 2012).

In recent years, drawing on lessons from growth accounting exercises, which show that improvement in productivity is essential for sustained growth (Kim, 2019), a greater focus has been directed to the sources of productivity and the determinants of its stagnation in SSA countries. Calderon (2022) provides a synthesis of a growing strand of the literature that investigates aggregate productivity as the result of firm-level decision-making. While recognising resource reallocation across sectors and firms as one of the primary sources of productivity growth, this literature emphasises resource misallocation as a potential explanation of low productivity (levels and growth) in SSA. This literature argues that inefficiencies of allocation of inputs (such as capital, land, and labour) across production units of varying sizes are the outcome of prevalent policies and institutions (including social norms) in SSA countries that drive production units away from productivity efficiency benchmarks. To boost productivity growth in SSA countries, the implications of this strand of research emphasise introducing innovative solutions to reduce sources of misallocation, such as imperfections in land market, agricultural support programmes, trade policies, taxation and informality, financial markets, infrastructure service provisions (transport, energy, digital infrastructure).

However, while pointing to distortions induced by policies and institutions, the mainstream studies do not explore the processes underlying the productivity growth at firm level. As argued in the critics of neoclassical economics by proponents of evolutionary economics theory, mainstream studies of growth do not focus on the technological learning and innovation processes that are at the core of growth dynamics; they pay less attention to the capabilities and their underlying accumulation processes, which underpin productivity improvement at firm and country level (Nelson & Winter, 1982; Nelson, 2008; Sainsbury, 2020; Sutton, 2012; Teece, 2019).

The literature on structural change, which was revived by Herrendorf et al (2014) and Duarte & Restuccia (2010) following the sustained growth acceleration in Asia and the recent growth spurs in SSA, has focused on the depth and patterns of structural transformation in SSA to provide potential explanation for the lack of sustained growth in the region. Duarte and

Restuccia (2018) report evidence of slow pace of structural transformation in SSA, finding that a large share of the growing population in this region continues to work in low-productivity agricultural sector. Other scholars have investigated the patterns of structural transformation in SSA and reported two unexpected results. One, unlike other developing countries in Asia and Latin America, economies in SSA have not seen a significant increase in the share of labour force employed in manufacturing sector. Instead, the shift in employment share has been towards the service industry, which historically has been less productive than manufacturing in other countries (de Vries et al.2015; Diao et al.2017; Enache et al. 2016; McMillan & Harttgen, 2014). Second, unlike in Asian economies where both within-sector productivity growth and inter-sectoral structural change have made a strong and positive contribution to overall productivity growth, countries in SSA experienced decline in labour productivity within modern, non-agricultural sectors such as manufacturing during their growth acceleration period (Diao, Ellis et al., 2021; Diao, McMillan & Rodrik, 2019: Diao et al. 2017, McMillan & Zeufack, 2022).

However, the structural change literature does not explain what is driving the patterns of structural transformation in SSA, offering little policy implications for reversing the trends. With respect to the slow pace of structural transformation, Nissanke (2019) attributes it to the macroeconomic policies of neoclassical inspiration. He takes a policy position stressing that "conventional macroeconomic_policy framework, with its focus on maintaining macro stability is inadequate for the purpose of accelerating the structural transformation of African economies"(Abstract). He explores an alternative framework, wherein a resolution of the short-run trade-off between the macroeconomic policy objectives of stabilisation and development is sought in terms of a long-term development approach for enhancing both aggregate demand and supply capacity as an anchor for navigating a path towards structural transformation. In such a framework, macroeconomic policies are applied coherently to one another and in coordination with other policies. This framework had been endorsed and advocated by the UN Economic Commission for Africa's report (UNECA 2017).

The alternative framework proposed above is consistent with the unifying framework proposed in Rodrik (2013b) and McMillan, Rodrik, and Sepúlveda (2017) as an affective approach for achieving and sustaining rapid growth. The framework acknowledges the role of investing in both macroeconomic growth fundamentals and structural transformation. It suggests that poor countries can experience structural transformation and growth take-off even when fundamentals are weak, as was the case in East Asian countries; however, if the country does not ensue improvements in fundamentals, growth driven by structural change will not be sustained.

However, the recent experience of SSA countries does not support the expectations of the unifying framework, as evidenced by growth decelerated from 2015-16 in many resource-rich and resource-poor countries. Yet, many of these countries are reported to have undergone structural transformation from the early 2000s (Busse et al., 2019; Diao et al., 2019; McMillan & Harttgen, 2014; McMillan, Rodrik & Verduzco, 2014; Timmer et al., 2014). They are also commended for having significantly improved their growth fundamentals on many dimensions (Rodrik, 2018; Mckinsey Global Institute, 2016; McMillan & Harttgen, 2014; OECD, AfDB, UNDP, & UNECA, 2013; Radelet, 2010). This puzzling outcome suggests that something else, something policy-induced other than just an improvement in growth fundamentals and structural transformation must be involved in affecting the ability of sub-Saharan economies to sustain rapid growth.

A cursory look at different metrics of the complexity of the countries' economies and the products that they export on a competitive basis reveals key features that are relevant for understanding countries' diversification patterns and prospects for sustained growth. SSA countries are positioned in the bottom ranking by economic complexity. For example, the economic complexity index (ECI) published by the Harvard Growth's Lab, which is a holistic measure of the productive capabilities embedded in a country's economic system, ranks all SSA resource-rich countries in the bottom quartile. The same can be said for the economic fitness (EF) ranking published by The World Bank, which is both a measure of a country's diversity and ability to produce complex goods and services on a globally competitive basis. Similarly, based on the countries' export baskets composition presented in the Atlas of Economic Complexity at Harvard Growth' s Lab and the available complexity rankings of products/sectors (e.g. Atlas of Economic Complexity, Observatory of Economic Complexity, Patelli et al., 2022), it is evident that SSA countries are to an extreme extent specialised in the products/sectors that are in the bottom of the complexity ranking, such as agricultural products, minerals, oil and gas which are associated with low productivity and wages.

The features of productive structures complexity in sub-Saharan economies suggest that the economic complexity approach and its underpinning capability-based theory of growth may be highly relevant in addressing the issue of diversification, productivity improvement and sustained growth in SSA. The present PhD thesis, therefore, adopts the economic complexity framework to solve the mystery surrounding the lack of rapid sustained growth in SSA.

The economic complexity framework describes the economy as an "evolutionary process of globally interconnected ecosystems"(Pugliese & Tacchella, 2021, p. 1) in which heterogeneous agents (firms, consumers, investors) interact and adapt to one another and their environment (Balland et al., 2022; Sbardella, Zaccaria et al., 2021). Its proponents argue that "some of the biggest societal issues of our time only start to make sense if we look at the systemic interactions that produce them"(Balland et al., 2022 p.1).

Building on a conceptualization of economic development as "a process of learning how to produce (and export) more and new complex products", the economic complexity places itself in the broad perspective of heterodox Economics and gives a central role to the diversity of a country's economy and the complexity of the products it produces and exports (Hausmann & Hidalgo, 2009; Cristelli et al., 2013). It stresses that what a country produces and exports matters for growth and development more than how much value it extracts from its products (Hausmann, Hwang, & Rodrik, 2007).

The economic complexity approach to growth and development can allow us to use the complex network methods to quantify the capabilities embedded in the countries' productive structures and to use the resulting metrics as a potential determinant when modelling the growth process. In doing so, we can extend the standard neoclassical-based growth regression model, and this opens a new possibility to reduce potential omitted variable bias in standard aggregate growth model and jointly test the hypothesis of resource curse against other potential capability-based traps. This approach also makes it possible to identify different growth regimes through which countries go through during their development process and to analyse their growth potential and dynamics. Furthermore, when combined with relatedness metrics in the network of product progression network, the economic complexity approach will allow us in this study to use fine-grained data on world exports to evaluate how the productive structures evolve and determine the patterns of specialization and change in industrial sector competitiveness. Where relevant, we can compare SSA countries to the rest of developing and emerging economies on one hand, and SSA resource-rich with their resource-poor counterparts on the other, in an attempt to draw insights and lessons for sustained growth and development policies.

1.3. RESEARCH QUESTIONS AND OBJECTIVES

Drawing insights from the capability theory of growth and leveraging economic complexity methods, this Ph.D. study aims to: (i) unravel the respective roles of natural resources and productive capabilities in accounting for rapid growth faltering in SSA; (ii) explore in depth the role of productive capabilities in shaping the patterns of structural transformation and driving the growth potential and dynamics of sub-Saharan resource-poor and resource-rich economies. The central question is: Why do sub-Saharan economies more than often fail to sustain rapid growth despite the tremendous opportunity afforded by the existence of significant sectoral productivity gaps to improve productivity growth? More specifically, we attempt to provide answers to the following three related questions:

1. Why do sub-Saharan countries more than often fail to sustain rapid growth and catch up rapidly—a curse of natural resources or a trap of development stasis?
2. To what extent are the capabilities embedded in sub-Saharan countries' productive structure systems and their changes over time a constraint or an enabler for their transition from growth acceleration to sustained growth?
3. To what extent are the accumulation of capabilities embedded in productive structures and their upgrading relevant in shaping the patterns of structural transformation and driving the industrial sector competitiveness in sub-Saharan countries?

This Ph.D. study looks at these questions with an economic complexity and product space lens. We argue that scant incentives to accumulate complex productive capabilities and ineffective processes to upgrade them are what is lacking for sustaining rapid growth; they are what distinguishes between countries that sustain growth and those that fail. Further, we argue that a shift in policy would be required away from excessive focus on "ensuring sound macro fundamentals" to supporting the underlying processes of complex capabilities accumulation at firm, industry and country levels in order to end the curse of high-frequency growth "up-breaks" and "down-breaks" in both sub-Saharan resource-poor and resource-rich economies.

To achieve the aim of this study, we rigorously address the above questions by combining methods and tools from econometrics and economic complexity in a manner that has not been attempted in previous works on empirical growth research in SSA. We complement the mainstream regression-based approach by going beyond aggregate modelling and taking a more fine-granular approach. This allows us to dive into countries' productive structures in order to quantify their relative competitiveness and assess individual country growth potential and dynamics. This approach also permits us to conduct the analysis of changes in productive structures and patterns of countries' specialisation, which are regarded as a reflection of a country's underlying productive capabilities behind sustained long-run growth (Hidalgo & Hausmann, 2007; Hausmann & Klinger, 2006, Sbardella, Zaccaria et al. , 2021).

More specifically, to answer the first question, we adopt a regression-based approach used in empirical literature on the natural resource curse. This is for comparability with the existing works. However, differently from previous research, we explicitly acknowledge the potential role of the capabilities embedded in a country's productive structure, as captured by economic complexity metrics. We include it as an explanatory variable when modelling the long-term growth dynamics. A priori, this strategy allows an unbiased estimation of the long-term growth effects of natural resources and country productive capabilities in a single regression model. It has a potential advantage of reducing the potential bias resulting from picking up the effect of omitted variable through the coefficient of natural resource. As we will discuss later in this study, the consequence of such bias is often the rejection of the null hypothesis of no resource curse while in fact it is true[8].

To account for the heterogeneous dynamics of the growth process and the interconnectedness of economic systems (Cristelli, Tacchella, & Pietronero, 2015), we supplement the regression-based approach with non-parametric methods rooted in complex network analysis. Thus, to answer the second question, we rely on the metrics of economic complexity that quantify the productive capabilities embedded in individual countries 'productive structures. These metrics are derived from using countries 'export data and leveraging complex network theory. The comparison of these non-monetary metrics of a country's intangible assets with monetary metrics, such as GDP per capita, allows the analysis of growth potential and dynamics for individual countries (Cristelli, Tacchella, Cader et al., 2017; Cristelli, Tacchella, & Pietronero,

[8]As we will discuss later in this study, when the omitted variable is positively correlated with the dependent variable, but negatively correlated with the included independent variable, there will be an omitted variable downward bias. In this case, the estimated coefficient on the dependent variable picks up the effect of the omitted variable. Consequently, this will lead to falsely rejecting the null hypothesis.

2015). It also allows for the building of selective predictability schemes (SPS) which are used to predict growth with higher precision than standard growth forecasting models used by the IMF, which rely on many variables and parameters (Tacchella et al. 2018).

To address the third question, we rely on the dynamic of each country's economic complexity metrics over the 1996-2018 period and their decomposition by industrial sector. The analysis of the emerging patterns allows us to evaluate not only the overall dynamics of structural transformation for individual countries but also their evolving specialisation and competitiveness across different sectors of various complexity levels. Furthermore, we use relatedness metrics defined in the product space network and their time evolution to examine the extent to which the capabilities embedded in the countries' productive structures enabled them to diversify and upgrade into ever-increasing complexity sectors associated with higher productivity.

1.4. SIGNIFICANCE AND CONTRIBUTION

This PhD study's ambition is to add in significant ways to the scholarly research on economic growth in Africa, deriving novel policy implications for sustaining rapid growth and achieving faster development. First, adopting an evolutionary econometric approach, this PhD contributes to the literature on endogenous growth models by focusing on the role of capabilities accumulation and upgrading that underpin technological learning and innovation, and are at the core of growth process (Nelson, 2008, Lall, 2000). As pointed out by Hausmann and Hidalgo (2009), the second generation of endogenous growth theories[9] builds on Lucas (1988)'s argument[10] by assuming a continuum of products in some technological space, where there is always a slightly more advanced product that countries can move to as they upgrade their technology, However, these models abstract from the space of products and ignore the role of structural transformation and heterogeneity of inputs when modelling growth, mainly due to the lack of tools to measure them empirically. By using economic complexity methods to quantify the complexity of the capabilities embedded in a country's productive structure and then using this metrics as a potential determinant of growth, we not only revive the idea

[9] The varieties model of Romer (1990) and the quality ladders of Grossman and Helpman (1991) and Aghion and Howitt (1992)
[10] Lucas (1988) argued that "a growth miracle sustained for a period of decades thus must involve the continual introduction of new goods, not merely continual learning on a fixed set of goods"(Lucas p..).

intuitively behind the Schumpeterian-based endogenous growth models, but more importantly, we reduce the potential omitted variable bias inherent in any growth regression model that ignores the role of country's productive structure (Sbardella et al., 2018).

Second, this PhD contributes to the literature on evolutionary theory of growth. The parametric-based approach commonly used in the mainstream growth empirics often fails to capture the highly heterogeneous features of the growth process. It led to what some scholars view as " wrong economics" in the context of growth research in Africa (See Jerven,2014; Obeng-Odoom F, 2017). By combining economic complexity metrics (a non-monetary measure of intangible assets) with monetary measures such as the gross domestic products (GDP), this PhD study uses a non-parametric approach based on the tools of dynamical system theory to analyse the growth potential and economic dynamics of resource-poor and resource-rich countries. In doing so, we innovate on the methodology for analysing growth performance between the two groups of countries. By adopting the evolutionary approach, we identify different growth regimes and the changing interactions between economic complexity, the other relevant growth determinants, and economic growth, which is useful for understanding why improvements in chosen growth fundamentals may lead to unexpected outcome on the dynamic of growth in different countries.

Lastly, this PhD study contributes to the empirical literature on structural transformation in Africa. As recognized by Diao et al. (2017), until the last decade, Africa had been absent from the literature on structural change. The emerging literature since the paper by McMillan and Rodrik (2911) has focused on sectoral productivity decomposition analyses, with lamentations regarding data reliability and limited coverage of countries. Building on insights from complex network theory, we apply metrics of economic complexity and relatedness in the product space to analyse structural transformation. These metrics are computed from a novel integrated dataset on countries' exports disaggregated at fine-grained sectoral level, covering virtually all SSA countries. Such analysis underlines the capacity of countries to accumulate and upgrade their productive capabilities as being the forces driving the speed and patterns of structural transformation, which is essential to understand the path-dependency phenomenon that emerges in the process of countries' specialisation and limit their prospects for improving productivity and sustaining growth.

1.5. STRUCTURE OF THE STUDY

The plan of this thesis is as follows. The second chapter reviews and assesses relevant literature, focusing on two main traditional perspectives which have been used to explain economic convergence and growth. We cover the main variants of the neoclassical growth model and the structural transformation literature. The third chapter extends the literature review to delve more in the resource curse theory, which has received much attention in the context of resource-rich countries in SSA. We explore the theoretical approaches that have been proposed to explain the resource curse and assess the empirical literature for potential gaps and further research. The Fourth Chapter lays down the economic complexity and product space framework. We define the underpinning concept of capabilities and its underlying accumulation processes, present the theoretical grounding, analytical framework and implications for economic growth and development of economic complexity. We also cover the metrics of economic complexity and product space, exploring their relationship with structural transformation and growth based on existing empirical body of evidence.

In the Fifth Chapter, the study empirically addresses the first question of why growth is faltering in sub-Saharan countries, focusing on the roles of natural resources and the country's productive capabilities. The Sixth Chapter tackles the second research question. It quantifies and compares the competitiveness of SSA countries in terms of the productive capabilities endowed in their economic systems; it also relies on the combination of the economic complexity metrics with per capita income to unveil the hidden growth potential and dynamics of individual sub-Saharan countries. The Seventh Chapter confronts the third question and focuses on examining the patterns of productive structures dynamics, industrial sector specialisation and relative competitiveness, based on complex network methods. The Eighth Chapter discusses the results, draw policy implications and provides a summary conclusion.

CHAPTER 2
THEORETICAL FRAMEORKS FOR ECONOMIC CONVERGENCE AND GROWTH

2.1. INTRODUCTION

In his paper "Understanding Patterns of Economic Growth: Searching for Hills among Plateaus, Mountains, and Plains," Pritchett (2000) observed shifts in growth rates of GDP in developing countries that lead to distinct patterns. He observed that "some countries have steady growth (hills and steep hills), others have rapid growth followed by stagnation (plateaus), rapid growth followed by decline (mountains) or even catastrophic falls (cliffs), continuous stagnation (plains), or steady decline (valleys) [Abstract]. He highlighted that growth differences over time within a country were as much as they differ among countries.

The patterns described by Pritchet are the key features of modern economic growth and have been widely documented. Starting with Lucas (1988), this scholar observed many examples of growth decelerations and accelerations in developing countries that are sudden and large. His examples of sudden downward change in growth rates included Angola (4.8 in the 1960s to -9.2 in the 1970s) and Iran (from 11.3 to 2.5 in the same period). Countries with sharp increases included South Korea, Taiwan, Hong Kong, and Singapore, where per capita GDP grew at rates of 7.0, 6.5. 6.8 and 7.5 percent respectively, for the 1960-80 period compared to much lower rates in the 1950s and earlier. They also included Indonesia (3.9 to 7.5) and Syria (4.6 to 10) between the 1960s and the 1970s. On their part, Hausmann et al. (2005) identify eighty-three episodes of growth accelerations since the 1950s, some of which were sustained. Rodrik (2011) identifies 24 instances of growth miracles since the 1950s—Diao et al. (2019) identifies episodes of growth accelerations in developing countries from the mid-1990s. More recently, after two decades of growth tragedy, sub-Saharan countries experienced growth accelerations from the mid-1995 followed by growth down-break in many of these countries by 2015 after the collapse in commodity prices. Yet some countries remain on the impressive growth governance path for two decades and a half following the footprints of emerging economies in Asia. How does the economy theory account for these growth differences both across countries and over time within countries? This question has attracted brilliant minds for several past decades since the seminal contribution by Robert Solow (1957).

In our attempt to provide answers to the research questions in this study, we first look at the two theoretical traditions that have been identified for examining and explaining growth and economic convergence. Rodrik (2014) and McMillan, Rodrik, & Sepulveda (2017) identify two main perspectives. The first is the "growth fundamentals" framework, which has its origins in macroeconomics and is underpinned by neoclassical growth models. The second is structural transformation, which has its roots in development economics and is grounded in the structural dualism approach to development. These two frameworks address the question of how growth happens in each economy and how it evolves in the long-term.

The structural approach to growth and development is rooted in development economics literature which emphasizes the dual-economy model (Lewis, 1954; Ranis & Fei, 1961) and the role of sectoral resource reallocation in spurring growth. This approach distinguishes between the traditional (agriculture) and modern (industry) sectors of the economy and emphasizes differences in the logics at work in both sectors, making it inconsequential for the two to be lumped together. It is assumed in this approach that: "Accumulation, innovation, and productivity growth all take place in the modern sector—often in unexplained ways— while the traditional sector remains technologically backward and stagnant" (McMillan, Rodrik, & Sepulveda, 2017, p.1). it is also assumed that there are significant productivity gaps between traditional and modern sectors of the economy, and these gaps are important sources of economic growth. Thus, in this structural approach, "economy-wide growth depends largely on the rate at which resources—principally labour—can migrate from the traditional to the modern sector" (Diao, McMillan, & Rodrik, 2019, p.286).

Scholars widely agree that structural dualism has evolved over time to include more than two sectors, and it now represents a relevant development paradigm rooted in a growing body of literature triggered by the growth accelerations experienced by the Asian countries in the 1980s and more recently in Africa. This body of literature includes the early contributions (Clark, 1957; Chenery; 1960, Kuznets, 1966; Syrquin, 1988, as cited in Diao, McMillan, & Rodrik, 2019) as well as the recent surveys of Herrendorf et al. (2014), Duarte and Restuccia (2010). The structural approach has given birth to the economic complexity approach, which leverages complex network theory to derive metrics aimed at quantifying changes in productive structures at a fine-grained level (see e.g. Hidalgo & Hausmann, 2009; Tacchella et al. (2012).

The "growth fundamentals" approach originates in macroeconomics and derives from the neoclassical growth model of Solow (1957) as extended in Mankiew et al. (1992). This approach is based on one sector model and does not distinguish between the traditional and modern sectors of the economy. It is built on a presumption that "different types of economic activity are structurally similar enough to be aggregated into a single representative one-sector model (McMillan et al. 201, p.4). In this conception, "factors of production are perfectly mobile across sectors of the economy, which results in equalization of their marginal products and rates of return" (Islam & Iversen, 2018, p.6).

Proponents of 'growth fundamentals' approach admit that differences in sectoral productivity exist at any point in time; however, drawing on neoclassical theory, they argue that these differences "are likely to be of minor magnitudes, because demand and supply situations are always changing, prompting the economy to adjust to the changes constantly, leaving no scope for large productivity differences across sectors to emerge" (Islam & Iversen, 2018, p.6). Broadly speaking, in this approach long-term growth depends on what is known as "growth fundamentals," such as the incentives to save, accumulate physical and human capital, improve the quality of institutions, etc. Subsequent variants of neoclassical models that endogenize technological change emphasise that economic growth depends on the capacity to innovate by developing new products and processes (Aghion & Howitt 1992; Grossman & Helpman 1991; Romer, 1990).

Associated with the question of how growth takes place in developing countries 'economies has been the issue of economic convergence. This issue emerged as economists started investigating the key economic question of whether "there are tendencies for the rich countries to grow richer and the poor ones to get poorer, so that the gap between rich and poor nations tends to widen over time." As recognised by Sala-i-Martin (1996), this question has been the focus of the empirical growth literature and captured the attention of mainstream macroeconomics theorists and econometricians from the late 1980s. Owing to the availability of a data set on internationally comparable GDP levels for a large number of countries from the late 1980s, testing of convergence became a powerful tool for the validity of modern theories of growth. The convergence research led to a wide array of empirical results and interpretations, even generating a feeling of exasperation among scholars (Islam, 2003).

In this Chapter, we review and assess the literature on economic models underpinning the two main traditional frameworks for examining and explaining growth, focusing on how convergence and growth accelerations have been addressed in these frameworks. This chapter is therefore organised into fuve major sections, as follows. Section 2 starts off by introducing the concept of economic convergence as defined empirically and the mechanism channels explaining it or lack thereof. Section 3 reviews the key features of neoclassical growth models, exploring their key assumptions and implications for economic convergence and growth. Section 4 focuses on structural transformation literature, focusing on its implications for convergence and on its patterns in developing countries. Section 5 draws some concluding remarks, underlying gaps for future research.

2.2. CONCEPT OF ECONOMIC CONVERGENCE

The estimation of convergence-rate parameters has been the focus of empirical growth research since the early 1990s. Its importance is articulated as follows in Barro (2012):

> Convergence-rate parameters are important to pin down because they provide guidance on how fast countries like China and India are likely to catch up to richer countries. The convergence rate may also reveal how fast a poor African country could develop or how rapidly North Korea could catch up to the South, and so on. (p.1).

However, as noted by Islam (2003) in his survey of literature on convergence, “excessive attention given to this issue led to many different interpretations of this concept and a wide array of empirical results”. As research on convergence proceeded over time, “different concepts of convergence emerged in the literature, often with certain dichotomies, reflecting different ways in which convergence has been interpreted in growth literature” (p.309).

Most notable among different concepts of convergence are (Islam, 2003, p.312): (a) “convergence within an economy vs. convergence across economies”; (b) “convergence in terms of growth rate vs. convergence in terms of income level”; (c) “β-convergence vs. σ-convergence”; (d) “unconditional (absolute) convergence vs. conditional convergence”; (e) “global convergence vs. local or club-convergence”; (f) “income-convergence vs. TFP (total factor productivity)-convergence”; and (g) “deterministic convergence vs. stochastic convergence”.

Conceptually relevant for this study are the concepts of "unconditional (absolute) convergence" vs. "conditional convergence," and "convergence in terms of growth rate" vs. "convergence in terms of income level." We defer the definition of the latter type of convergence until after we officially introduce the neoclassical growth model. We say that "there is unconditional (absolute) β-convergence if economies with lower levels of per capita income tend to grow faster in per capita terms than those with higher levels of income per capita" (Sala-i-Martin, 1996, p.1020). This concept "implies the existence of a negative correlation between the initial income level and the subsequent growth rate." This definition has led growth economists to develop an empirical methodology for testing convergence in data by running what is now known as "growth-initial level regressions." The coefficient associated with the initial income variable in these regressions (say, β) is supposed to capture the negative correlation. Convergence assessed based on the sign of β in a cross-country growth regression including the initial income and a constant as the only regressors is known as "absolute or unconditional convergence."

Following Sala-Martin (1996), assume we have data on real per capita GDP for a cross-section of economies between years t and t-1, and we estimate the following regression:

$$\boldsymbol{growthGDPpc_{i,t,}} = \boldsymbol{\alpha} + \boldsymbol{\beta} \ln \boldsymbol{GDPpc_{t-1,}} + \boldsymbol{\varepsilon_{j,t}} \qquad (1.1)$$

Where $\boldsymbol{growthGDPpc_{i,t,}}$is the growth rate of GDP per capita between t and t-1, and $\ln \boldsymbol{GDPpc_{t-1,}}$is the logarithm of GDP per capita of economy i at time t. "If we find $\beta \leq 0$, then we say that the data set exhibits "absolute convergence".

Barro (1991) and Barro and Sala-i-Martin (1991, 1992) introduced a closely related concept of "conditional convergence", as opposed to "absolute or unconditional convergence". Conditional convergence "is one in which countries purportedly differ in their long-run per capita income levels, with each countries tending to grow more rapidly the greater is the gap between its initial per capita income level and its ***own*** steady-state or long-run per capita income level." The steady-state income level of a country depends on its specific circumstances or "structural" variables, which we might call "growth fundamentals," that is, "the set of factors that condition long-run income levels" (Sachs &Warmer, 1995). While this set could be quite large in principle, typical conditioning or structural variables used in growth regressions include fertility rates, levels of investment, initial level of human capital, quality of institutions and policies, geography and ecology, colonial history, etc.

In Islam (2003), "unconditional convergence implies that all elements that determine long-run income levels are the same for the economies considered and there is only one steady state level of per capita income to which all economies approach" (p.315). In terms of the growth-initial level regression, this means that the sign of the coefficient associated with lag GDP (β) should be negative even if no other variable is included on the right-hand side of the growth regression. In contrast, the concept of conditional convergence emphasises differences in the set of factors that condition long-run income levels; it implies that equilibrium differs by economy, and each economy approaches its own but unique per capita equilibrium. Hence, conditional convergence "requires that appropriate variables be included on the right-hand side of the growth-initial level regression in order to control for these differences" (p.315).

Formally, let y_i* be the steady state or long-run per capita income level of country i, and y_i its initial per capita income level. The rate of growth, γ_i is assumed to be an increasing function of the gap between y_i* and y_i; that is:

$$\check{\Upsilon}\mathrm{i}_{\boldsymbol{i,t,}} = \boldsymbol{\beta}\,\mathbf{ln}(\mathrm{yi}* - \mathrm{yi}) + \boldsymbol{\varepsilon}_{\boldsymbol{j,t}} \tag{1.2}$$

Where yi* is proxied by "structural variables" mentioned above, according to an equation :

$$y_i^* = \Sigma\alpha_{ji}Z_{ji}$$

Rearranging the terms, one can estimate a regression of the form:

$$\check{\Upsilon}\mathrm{i}_{\boldsymbol{i,t,}} = \boldsymbol{\beta}\,\mathbf{ln}(\Sigma\alpha'_{\boldsymbol{ij}}\boldsymbol{Z}_{\boldsymbol{i,t,}} - \boldsymbol{y}_{\boldsymbol{i,t-1}}) + \boldsymbol{\varepsilon}_{\boldsymbol{j,t}} \tag{1.3}$$

A positive and significant β coefficient associated with the initial per capita income level y_i is interpreted as a finding of conditional convergence. It is conditional in the sense that "it holds only with an allowance for differences in constant or slowly varying cross-economy characteristics, such as saving rates or fertility rates or quantity of human capital or institutional quality or colonial history or geographical features" (Barro, 2012, p. 2). In other words, under the conditional convergence hypothesis, the lower is the level of steady state income of countries, the slower is their rate of convergence to the steady state from a given initial level of income (Barro & Sala-i-Martin, 1992). It follows that in countries where private property rights are not well protected, public investment and economic policies are inefficient , for example, we should expect to see lower steady state levels of income and a lower rate of growth (Barro, 1996). Barro pointed out that this is likely to be the case in many SSA countries that might not converge at all “if key underlying variables, such as the quality of human capital and institutions, were not improved” (Barro, 1912, p.2). For Rodrik (2018), this interpretation suggests that “developing countries will grow rapidly and converge to rich countries income levels only conditional on these disadvantages being overcome” (p.11).

The economic convergence phenomenon and the mechanism channels that explain its emergence are discussed in different traditional growth frameworks, emphasising different factors with different outcomes regarding long-term growth prospects. In what follows, we review how the convergence has been viewed in different neoclassical growth models.

2.3.NEOCLASSICAL GROWTH MODELS AND CONVERGENCE

2.3.1. Standard Neoclassical growth model

Up until the resurgence of interest in growth theory and empirics in the late 1980s, growth theory consisted of the neoclassical model, as presented by Ramsey (1928), Solow (1956), Cass (1965), and Koopmans (1965). Robert Solow (1956), who was awarded a Nobel Prize for his model of economic growth, considered a production function with two key factors—physical capital and (unskilled) labour—that were econometrically linked to explain economic growth. Solow recognised that technological change is an important contributing factor to economic growth, but in terms of his model, it was considered an “unexplained residual, which falls like manna from heaven.” Solow’s model assumes a production function with decreasing returns to capital. Taking the rates of saving and population growth as exogenous, he showed that these two variables determine the steady-state level of income per capita. His model gives simple, testable predictions about how these variables influence the steady-state level of income. The higher the rate of saving, the richer the country. The higher the rate of population growth, the poorer the country.

One of the key features of the neoclassical model, which has attracted intense debate, is the empirical hypothesis of the convergence property. In Barro (1991, p.407), Barro and Sala-i-Martin (1992, p.226), the authors point out that the main element behind the convergence property is the assumption of a "standard production function with decreasing returns to capital". It follows directly from this assumption that "the rate of return on investment and the rate of growth of per capita output are expected to be decreasing functions of the level of the per capita capital stock." Therefore, the low capital-labour ratio in poor countries, which have the advantage of economic backwardness, should raise the return to investment and accelerate economic growth in such a way that, over time, wage rates and capital-labour ratios across different countries converge, leading to economic catch-up.

The fundamental question in the empirical growth literature has been "whether the convergence property in the neoclassical growth model is consistent with the data." As noted by Sachs & Warmer (1997), owing to the efforts by economists to increase the availability and use of standardised data sets (e.g. Summers & Heston's Penn World Tables data set), there has been a growing empirical literature on cross-country growth, especially following the seminal work of Robert Barro (1991). In Barro (1991), the author begins by pointing out that "the hypothesis that poor countries tend to grow faster than rich countries seem to be inconsistent with the cross-country evidence, which indicates that per capita growth rates have little correlation with the starting level of per capita product" (pp.407-408). Based on data from the Summers and Heston (1988) international comparison project, he shows that "the average growth rate of real per capita gross domestic product (GDP) from 1960 to 1985 is not significantly related to the 1960 value of real per capita GDP" (p.408).

In an equation regressing the growth rate of real per capita GDP as the dependent variable on a constant term and the log of 1960 per capita GDP as the only independent variables, Barro reports findings showing that "there is lack of close relationship between the growth rate and the log GDP1960", with the estimate $\beta = -.0037$ (.0018). In fact, the convergence coefficient β has an unexpected sign; that is, "there is a small tendency for the initial rich countries to grow faster than the poor ones after 1960". This finding, he acknowledges, is in support of endogenous models, such as Lucas (1988) and Rebelo (1990), which assume constant returns to a broad concept of reproducible capital, including human capital". In these models, he goes on, "the growth rate of per capita product is independent of the starting level of per capita product" (Barro, 1991, p. 408). The finding regarding the absence of convergence has been supported in other empirical studies. For example, Sachs and Warmer (1995b) report findings that support a lack of convergence: an inverse relationship between initial income and subsequent growth rates. They observed that "many poor countries, particularly those in SSA, not only fail to grow faster than the rich countries, but they in fact also experience negative per capita growth, so that the gap between those countries and the rich countries widens significantly” (p.2).

To demonstrate the consistency of the traditional neoclassic growth model with the convergence property, Barro (1991), Barro and Sala-i-Martin (1991, 1992) introduced a closely related concept of “conditional convergence”, as opposed to “absolute or unconditional convergence”, by extending the Solow model.

One such notable extension was the broadening of the concept of physical capital to include human capital in the form of education, experience, and health (Barro, 1991; Mankiw, Romer &Weil, 1992). Barro (1991, 409-419) extended the Solow model in the empirical analysis using school-enrolment rates to empirically measure human capital. He shows that when controlling for set of certain variables, a significantly negative partial relation is found between the per capita growth rate and the log of initial per capita GDP in a sample of 98 countries. It is found that, for a given initial value of per capita GDP, subsequent growth rate of a country’s economy is positively linked to these measures of initial human capital. Moreover, given the human-capital variable, subsequent growth is negatively related to the initial level of per capita GDP. Thus, Barro concludes that, with this modification of the Solow model, the data support the finding of convergence as predicted by the neoclassical growth models. He emphasizes that "a poor country tends to grow faster than a rich country, but only for a given quantity of human capital; that is, only if the poor country's human capital exceeds the amount that typically accompanies the low level of per capita income" (p. 409).

Similarly, Mankiw et al. (1992) examine the convergence property using an augmented version of the Solow model that includes human capital. Their finding supports the Solow model prediction: countries reach different steady states. Examining empirically the set of countries for which no convergence has been widely documented in past work, they find that once differences in saving and population growth rates are accounted for, there is convergence at the rate that the model predicts. Overall, their results suggest that “international differences in income per capita are best understood using an augmented Solow growth model” (p.432).

The drive for establishing conditions under which conditional converge holds has led to the identification of a myriad of variables that, once controlled for, allow the convergence gap to exert significant leverage on actual growth (Rodrik, 2011). This author contends that “such regressions do not tell the policymaker what they are really after, which is the set of policies that guarantee convergence” (p.19). He made a point that developing countries can sustain rapid growth and converge to the income levels of developed countries if one thinks in terms of the difference in the productivity levels of the two groups of countries – on the “convergence gap.” In this sense, he argues, convergence depends on sustaining rapid structural transformation towards manufacturing products and modern services. This, he acknowledges, often requires unorthodox policies that are hard to emulate - such as currency undervaluation and industrial policies – which industrial countries will resist. Therefore, Rodrik regrettably laments that much of the convergence potential is likely to go to waste.

Despite the simplicity and attractiveness of the standard neoclassical growth model, in the late 1980s, scholars came to increasingly realise that its predictions fell short of providing a theoretical account of cross-country differences in income levels and growth rates. This turned out to be especially evident when the data set on internationally comparable GDP levels for many countries became available in the mid-1980s and opened way for searching alternative growth models.

For example, in his paper titled “On the mechanics of economic development,” Robert Lucas (1988) observes a great diversity across countries in measured per capita income levels between industrial market economies and poor countries. He also observes large diversity and striking differences in the rates of growth of real per capita GNP over sustained periods, ranging from 1.4% in India to 7% in South Korea and 7.1% in Japan for 1960-80. From a cursory analysis, it was evident to him that “poor countries tend to have the lowest growth, the wealthiest countries next, the middle-income countries highest” (p.4). In addition, he observes that within advanced economies, growth rates tend to be stable over a lengthy period, whereas for poor countries, there are many instances of sudden and large changes in growth. Noting that the standard neoclassical growth model was developed and applied to twentieth-century U.S. experience, Lucas assessed its predictions and concluded that:

> As it stands, the neoclassical model of growth is not an adequate model of economic development for two major reasons: Its apparent inability to account for observed diversity across countries and its strong and evident counterfactual predictions that international trade should induce rapid movement toward equality in capital-labour ratios and factor prices. (p.17).

Robert Lucas ‘conclusion supports Roomer’s (1986) contribution and sets the stage for a quest for alternative models of growth, giving rise to generations of endogenous growth models[11].

2.3.2. Endogenous Growth Models

Following Solow's (1956)'s seminal paper, subsequent economists relied on the “model of production function” as a basis for explaining the determinants of economic growth. However, it was quickly realised that the traditional factors—capital and labour—were inadequate in accounting for variation in growth performance. Indeed, it was the residual attributed to reflect exogenous technological change that typically accounted for most of the variations in economic growth. Mankiw et al. (1995) showed that the Solow neoclassical growth model leaves a high magnitude of income per capita unexplained when comparing international income differences, suggesting that this model suffered from serious omitted variable bias. Efforts by economists to account for the residual in the Solow model led to the introduction of macroeconomic “endogenous growth models” in which an alternative view of long-run prospects for growth is offered. Remarkably, one of the key departures from the standard neoclassical growth model is the assumption of non-decreasing returns to the set of reproducible factors of production (Aghion &Howitt, 1992; Grossman & Helpman, 1991; Lucas, 1988; Rebelo, 1991; Romer, 1986).

The first endogenous growth models, sometimes referred to as knowledge-based endogenous growth models”(Chirwa & Odhiambo, 2018), placed knowledge at the centre of economic growth. These models were standard except that capital was broadened to include human components and to allow for spillover effects (see, e.g., Lucas, 1988; Romer, 1986; Rebelo, 1991). Overall, these models emphasize that knowledge was a key factor in production, along with traditional factors of labour and capital postulated in the standard exogenous growth model. Moreover, because it was endogenously determined because of externalities and spillovers, knowledge was particularly critical in generating non-decreasing returns. In these models, “growth may go on indefinitely because the returns to investment in a broad class of capital goods, which includes human capital, do not necessarily diminish as economies

[11] Chirwa & (2018) provides a recent critical assessment of exogenous an endogenous growth model.

develop" (Barro, 1996, p.7). In other words, this class of models predicts economic divergence, not convergence.

To examine the convergence property, Romer (1986) proposed a model that offers an alternative view of long-run prospects for growth. This model assumes knowledge to be an input in production that has increasing marginal productivity and demonstrates that "in a fully specified competitive equilibrium model with endogenous technological change, per capita output can grow without bound, possibly at a rate that is monotonically increasing over time"(p.1003). He shows that, unlike in the traditional neoclassic model, "the rate of investment and the rate of return on capital may increase rather than decrease with increases in the capital stock." He argues, "[T]he level of per capita output in different countries need not converge." Moreover, he emphasises that "growth may be persistently slower in less developed countries and may even fail to take place at all." He also highlights that:

> These results do not depend on any kind of exogenously specified technical change or differences between countries. Preferences and the technology are stationary and identical. Even the size of the population can be kept constant. What is crucial for all these results, he stresses, is a departure from the usual assumption of diminishing returns. (p. 1003).

Like Romer (1986), Lucas (1988) proposes an alternative to the standard neoclassical model by considering a complementary engine to the technological change that serves this purpose in the Solow model. Following the theory of human capital (citing Schultz, 1963; Becker, 1964), he adds human capital to the standard model and shows that, when the role of international trade and learning-by-doing in the formation of human capital are considered, "the model predicts constant and endogenously determined growth rates". In addition, "it offers the possibility of different growth rates across countries, though differences that are not related to income levels" (p.36). Moreover, in a two-sector goods economy, the model predicts that "producing (having comparative advantage in) high-learning goods will lead to high-than-average real growth only if the two goods are good substitutes" (p.36).

Subsequent work on endogenous growth theory puts emphasis on technological advance though innovation and seeks to provide the missing explanation of "long-run growth." It argues that technological progress generated by the discovery of innovative ideas is the only way to avoid diminishing returns in the long run. If there is no tendency to run out of ideas, then growth rates can remain positive in the long run (Aghion & Hewitt 1992; Grossman & Helpman, 1991;

Romer, 1987, 1990). Chirwa and Odhiambo (2018) refer to these endogenous growth models as "Schumpeterian endogenous growth models of industrial innovation", because "they focused on quality-improving innovations based on Schumpeter's (1942) creative-destruction theory" (p.74). Further, and of particular relevance, long-term growth rate in these models "depends on governmental actions, such as taxation, maintenance of law and order, provision of infrastructure services, protection of intellectual property rights, and regulations of international trade, financial markets, and other aspects of the economy" (Romer, 1996, pp.7-8). Therefore, "the government has great potential for good or ill through its influence on the long-term rate of growth"(p.8).

Despite the breakthroughs achieved through the introduction of endogenous growth models, which endogenize the rate of technical change, some economists have pointed to their shortcomings. For example, they contend that "these models are less attractive in that they tend to lose the prediction of conditional convergence" (Barro & Sala-i-Martin, 1995, p.1), which is a strong empirical regularity in the data for countries and regions. Others point to empirical challenges with estimating the parameters of endogenous growth models, which often require the use of simulations (Chirwa & Odhiambo, 2018). To restore the convergence property, Barro, and Sala-i-Martin (1995) consider the diffusion of technology and construct a model that combines elements of endogenous growth (from the discovery of ideas in the leading-edge economies) with the convergence implications of the neoclassical growth model (from the gradual imitation by followers). With this extension, they show that in "the long run the world growth rate is driven by discoveries in the technologically leading economies." They argue that followers converge toward the leaders because copying is cheaper than innovation over some range.

2.3.3. Growth Fundamentals in Neoclassical Models

So, what are then the real forces behind economic growth and convergence? Is there a set of policies that guarantee rapid economic growth and convergence? As we have seen throughout the review and assessment in the preceding sections, there is no consensus as to what variables matter for growth and convergence (Helpman, 2005). Exogenous and endogenous growth models yield sharply contrasting predictions about long-term growth. The empirical literature on economic growth has established that convergence is not automatic (Rodrik, 2011); there is only conditional convergence, not unconditional convergence. But what are those conditioning circumstances? Which specific characteristics of countries have a causal effect on growth and convergence? These questions are especially relevant for policy.

A natural starting point for answering these questions is the discussion of conditional convergence in the previous sections, which emphasised the importance of certain country characteristics that might be related to the process of economic growth. As pointed out in Rodrik (2011), “[G]rowth econometricians have identified a long list of variables, which, once they are controlled for (individually or collectively), permit the convergence gap to exert significant leverage on actual growth” (p.19).

Typically, conditional convergence is expressed formally in relation (1.3) as follows:

$$\check{Y}_{i,t,} = \beta(\ln (y_i{*}\Theta) - \ln y_i) + \varepsilon, \qquad (1.4)$$

Where Θ_i is “a vector of country-specific circumstances (variables) determining the long-run income level.” What goes into Θ_i are what growth econometricians refer to as “growth fundamentals”—that is, “the set of factors that condition long-run income levels” (Rodrik, 2016, p.4). As indicated above, conditioning variables used in growth regressions include such factors as levels of investment, human capital, quality of institutions and governance, measures of macroeconomic stability, trade openness, natural resource exports, and private property rights protection, etc. As rightly recognised by Rodrik (2011, p.19), [T]he estimated coefficient on initial income typically turns negative and statistically significant as soon as one throws any combination of these variables on the right-hand side of a growth regression” (citing Barro, 1991, 1996; Barro & Sali-i-Martin, 1992; Mankiw et al., 1992; Sachs & Warmer;1997). These papers suggest that convergence may be achieved only after countries attain a threshold of income or human capital.

A strand of research has emphasised the role of policies in achieving convergence. For example, in their paper titled "Economic Convergence and Economic Policies", Sachs and Warmer (1995b) present evidence suggesting that a sufficient condition for poorer countries to achieve economic convergence is that these countries follow “reasonably economic policies”, outward-oriented trade policies and protection of private property rights. They argue that “poorly managed economies - such as those with the absence of secure property rights, autarkic policies, inconvertible currencies, and so forth- are unlikely to experience convergence no matter what the underlying production technologies or initial level of human capital” (p. 5).

These scholars downplay the role of technology and human capital for achieving economic convergence and emphasize the role of adequate economic institutions and policies.

Defining a set of countries that have sustained "appropriate" market-based economic policies during the period 1970-89, Sachs and Warmer went on to empirically examine whether there is a tendency towards convergence among what they categorise as a set of ‘qualifying countries’ during this period. In their findings, they note an overwhelming tendency towards convergence, even among countries that start with extremely low levels of human capital endowments and extremely low levels of initial per capita income. They emphatically stressed that “it is hard to find a single case in which a poor country actually protected private property rights, maintained economic openness, and yet failed to achieve economic growth” (p. 6). .

The role of policy and institutions in achieving convergence is also asserted in a famous quote from the lecture that Larry Summers gave some years ago, in which he castigates the sceptics who make adverse comments about the determinants of convergence. Quoting Summers, Rodrik (2011) writes:

> I would suggest that the rate at which countries grow is substantially determined by three things: their ability to integrate with the global economy through trade and investment; their capacity to maintain sustainable government finances and sound money; and their ability to put in place an institutional environment in which contracts can be enforced and property rights can be established. I would challenge anyone to identify a country that has done all three of these things and has not grown at a substantial rate. (pp.19-20).

Taking a closer look at this statement, Rodrik (2011) retorts that "what appears at first sight to be a sweeping affirmation of the robustness of our knowledge about what countries need to do is an ingeniously crafted hedge which illustrates and reinforces my point about the extent of our actual ignorance". He points out that “by resorting to the ability and capacity to achieve outcomes that are systematically correlated with growth instead of the actual policies that deliver those outcomes, summers ‘statement ducks the hard questions.” The “ability” to do X and “capacity” to manage Y “do not tell us what the requisite policies are.” (p. 20).

An legitimate question that has been raised is whether all the conditioning variables used in growth regression are fundamental causes of growth. Acemoglu and Johnson (2005) recognise that these variables are consistent with the traditional neoclassical growth models that place different paths of factor accumulation at the centre of cross-country differences in income per capita. They are also consistent with different variants of endogenous growth models in that “these models also stayed squarely within the neoclassical tradition of explaining differences in growth rates in terms of preferences, endowments and innovations” (p. 388). However, they quickly point out that “though this theoretical tradition is still vibrant in economics and has provided many insights about the mechanics of economic growth, it has for a long time seemed unable to provide a fundamental explanation for economic growth” (p.388).

In Acemoglu (2007), the author argues that any growth theory that solely focuses on technology, physical capital, and human capital differences across countries is, at some level, incomplete. He writes:

> If technology, physical capital and human capital are so important in understanding differences in the wealth of nations and if they can account for many-fold differences in income per capita across countries, then why is it that societies do not improve their technologies, invest more in physical capital, and accumulate more human capital. (p.155)

Acemoglu believes that there must be some other reasons underneath those reasons, which he refers to as “fundamental causes of economic growth”, vehemently arguing that: "[It] is these reasons that are preventing many countries from investing enough in technology, physical capital and human capital"(pp.155-156).

Following North and Thomas's (1973)'s theoretical approach, which distinguishes between what they dub “proximate” and “fundamental” determinants of economic growth, Acemoglu, Johnson, and Robinson (2005) argue that, the factors emphasised in traditional neoclassical and endogenous growth models (innovation, economies of scale, education, capital accumulation, etc) are only proximate causes of economic growth and economic success. They support North and Thomas's view and present a theoretical and empirical case showing that differences in economic institutions are the fundamental cause of differences in economic development. Later in Acemoglu and Robinson (2010), the authors point out that “the notion that incentives matter is second nature to economists, and institutions, if they are a key determinant of incentives, should have a major effect on economic outcomes, including economic development, growth, inequality, and poverty” (p.136).

But what institutions are the most relevant for economic growth and development outcomes? In Acemoglu et al. (2005), Acemoglu and Robinson (2010), the authors stress that, of primary importance to economic outcomes, are the economic institutions in society, such as the structure of property rights and the presence and perfection of markets. For these scholars, “economic institutions are important because they shape the structure of key economic actors in society” (p.384). They state that “without property rights, individuals will not have the incentive to invest in physical or human capital or adopt more efficient technologies.” Moreover, they argue, “economic institutions are also important because they help to allocate resources to their most efficient uses; they determine who gets profits, revenues, and residual rights of control”(p.385). While not dismissing the importance of sources of growth identified in exogenous and endogenous growth models, they stress that only “societies with economic institutions that facilitate and encourage factor accumulation, innovation and the efficient allocation of resources will prosper" (Acemoglu et al. 2005, p. 389). Therefore, they conclude that to solve the problem of development, it will entail reforming these institutions.

But are institutions the only potential source of economic growth and cross-country income differences? Although Daron Acemoglu, James Robinson, and assorted co-authors forcefully argue that institutional differences are a primary determinant of economic outcomes, they also recognise that there are innumerable fundamental causes of economic growth that various economists, historians, and social scientists have proposed over the ages. In his book, “Introduction to Modern Economic Growth,” Acemoglu (2007, cha.4) identifies and classifies the major candidate fundamental causes of economic growth under four categories of hypotheses. These include: (i) *the luck hypothesis (citing* Jones & Olken, 2005); (ii) t*he geography hypothesis* (citing Montesquieu, 1748; Alfred Marshall, 1890, Jared Diamond, 1997; Sachs, 2001, 2000; Bloom & Sachs, 1998; Gallup & Sachs, 2001); (iii) t*he culture hypothesis* (citing Weber, 1930; Banfield,1958; Putnam,1993); and (iv) t*he institutions hypothesis (*Acemoglu et al., 2005). Acemoglu reviewed the empirical evidence in favour of and against the various hypotheses. He concludes that, “by and large, this evidence suggests that institutional differences that societies choose and end up with are a primary determinant of their economic fortunes” (p.175). This conclusion is further supported by empirical evidence in Acemoglu, Gallego, & Robinson (2014), who found that differences in institutional quality account for as much as 75% of the variation in income levels around the world. On a sceptical tone, Rodrik (2018) observes that, although this is about cross-country differences in income levels, not growth, it is huge as a contribution from institutions.

Despite the attention received by the institution hypothesis in the economic development literature, there has been a debate over “whether institutions cause economic growth or whether, alternatively, economic growth and human capital accumulation lead to institutional improvement." An alternative approach has emerged that supports the reverse idea supported by North and Thomas (1973), namely that growth in income and human capital causes institutional improvements. Proponents of this approach view the process of economic growth and development as originating from human capital accumulation; they see institutional improvements as the result of increased education and wealth, not as their causes (Glaeser et al., 2004; Glaeser, Ponzetto, & Shleifer, 2007). These scholars criticise Acemoglu et al. (2005) for "putting the institutional cart before the human capital horse".

In response to the paper by Glaeser et al. (2004), Acemoglu et al.(2014) revisit the relationship among institutions, human capital, and long-run economic development. They argue that because of failure to account for endogeneity and measurement error in institutions and human capital variables in the growth regression models, previous works suffer from the usual omitted variable bias problems. They show that this misspecification leads to an upward bias in the estimates of the human capital returns, about four to five times greater than those implied by micro (Mincerian) estimates found in the previous literature. Using cross-country and cross-regional regressions, they show that once one controls for the historical determinants of institutions and human capital, or simultaneously treats both variables as endogenous, the estimates of the effect of human capital on long-run development decline significantly and are often in the range of 6–10%, consistent with the micro (Mincerian) evidence—although they are not always significantly different from zero. Moreover, they show that the impact of institutions on long-run development remains qualitatively and quantitatively robust regardless of whether human capital is included in the regression (and treated endogenously) or whether historical determinants of education are directly controlled. They conclude that this evidence supports the view that institutions are the fundamental cause of long-run development, working not only through physical capital and TFP but also through human capital.

Notwithstanding this long-standing debate about the fundamental causes of growth, there is a large consensus among development economists that institutions and human capital are both fundamental causes for growth and development differences across countries (see e.g., McMillan, Rodrik, & Sepúlveda, 2017; Rodrik, 2018). Therefore, as to what the true growth fundamentals are, we take side with Dani Rodrik, who does not take a strong stand among the contending perspectives but simply states that "[A]s long as we leave room for human capital and institutions, I am happy to accept that geography matters too" (Rodrik, 2018, p. 12).

Another important issue that has generated greater debate in this literature is the surprising features of modern economic growth, which is that economies with abundant natural resources have tended to grow less rapidly than natural resource-scarce economies (Sachs & Warmer;1995); Following this groundbreaking paper, a flourishing literature has emerged over the last three decades that explores the mechanism channels through which natural resources affect growth and empirically test their economic and statistical significance. Despite intensive research, survey of literature and meta-analysis studies have found that the evidence is mixed. There is no consensus as to whether natural resources are a curse or a blessing (see recent survey studies by Alssadek & Benhin, 2023; Badeeb et al., 2017).

2.3.4. Neoclassical models and growth turning points.

For decades since Solow's (1956) seminal paper, it had been difficult for economists to make sense of economic growth patterns with aggregate models (Hidalgo & Hausmann, 2011). The growth empirics remained focused on identifying the fundamental causes of growth and determining the steady-state level of income per capita in the context of growth convergence debate. However, despite the sophisticated econometrics methods and techniques applied, the different assumptions regarding the returns to the reproductible factors of production, which underline exogenous and endogenous growth theories yielded sharply contrasting predictions about the patterns of growth and its long-term prospects. Whereas exogenous growth models predict convergence to the steady state income levels, models which endogenous growth predicts perpetual growth with growing divergence in income levels between developed and poor countries. In both types of models, the implications of a (permanent) improvement in “growth fundamentals” at time T are different (Hausmann et al., 2005).

Pritchett (2000) discusses the implications of the observed growth patterns for econometric research, arguing that “the use of high-frequency panel data, particularly with fixed effects, to investigate long-run growth correlates is almost certainly pointless”(p.222). He suggests that the nature of growth instability calls for research into the determinants of shifts in growth rates, focusing on episodes of growth or policy changes. Following Lant Pritchett’s paper, a strand of literature, referred to as “turning points growth literature,” has emerged that looks into what initiates (or halts) episodes of growth accelerations and their sustainability (Hausmann, 2005; Jerzmanowski, 2006; Aizenman & Spiegel, 2010). Observation that some episodes of growth acceleration last longer than others led to subsequent research papers focused on better understanding what accounts for the duration of sustained growth episodes (Berg, Ostry, & Zettelmeyer, 2012; Kerekes, 2012; Tsangarides, 2012; Arizala, Gonzalez-Garcia, Tsangarides, & Yenice, 2017), and the duration of growth declines (Hausmann, Rodriguez, & Wagner, 2006; Bluhm et al., 2014).

The literature on growth turning points addresses the issue of transition in different growth regimes as reflected in the patterns of growth. It first identifies the turning points in growth experience and attempt to identify what factors determine these transitions. For example, Hausmann , Pritchett and Rodrik (2005) empirically use methods that begin by identifying growth episodes and then examine their determinants. They run probit regression models where the dependent variable is regressed on several determinants categorised under three headings (external shocks, political changes, economic reform).Their results brought some interesting insights. First, they find that growth accelerations are quite frequent. Second, growth accelerations tend to be correlated with increases in investment and trade, and with real exchange rate depreciations. Third, political-regime changes are statistically significant predictors of growth accelerations. Fourth, the nature of other determinants depends on whether the acceleration is sustained into the longer term or not. Finally, and perhaps most importantly, they find that growth accelerations tend to be highly unpredictable: “most growth accelerations are unrelated to standard determinants such as political change and economic reform, and most instances of economic reform do not produce growth accelerations (p.305)

Distinguishing between growth accelerations that are sustained and those that are not, Hausmann and co-authors use them as the dependent variable and derive interesting results, showing that there are significant differences in the determinants of the two types of growth accelerations. Their results strongly suggest that “sustained and unsustained growth accelerations tend to be triggered by different conditions. Financial liberalisation and positive external shocks are associated with growth accelerations that eventually fizzle out. Fundamental economic reform and positive political regime change increase the likelihood of sustained accelerations” (p.323).

Hausmann and co-authors were surprised by their findings, that standard growth determinants of neoclassical inspiration have some statistical leverage over the timing of accelerations, although they are poor predictors of the growth turning points. The finding that standard neoclassical growth determinants are significant in triggering growth is confirmed by

Jerzmanowsk (2006). He estimates a Markov-switching regression to characterise four distinct growth regimes (stable growth, miracle catch-up, stagnation and crisis). and transitions between them. His results suggest that countries switch among regimes, with the transition probabilities determined by the quality of institutions. Countries with better institutions are likely to sustain long-run growth by making episodes of fast growth more persistent. Countries with weak institutions can experience growth take-offs, but the sustainability of such growth episodes is limited.

Similarly, Aizenman & Spiegel (2010) identify factors associated with take-offs – "a sustained period of high growth following a period of stagnation". Using probit estimation, they find that de jure trade openness is positively and significantly associated with take-offs, with a 55% increase in the probability of a take-off from one standard deviation increase in openness. Capital account openness plays some role, although it is not robust, but measures of de facto trade openness, as well as a variety of other potential conditioning variables, were found to be poor predictors of take-offs. The study fails to find a significant role for openness in determining whether take-offs are sustained but does find a role for output composition. Countries with more commodity-intensive output bundles were found to be less likely to sustain take-offs relative to countries that are more service-intensive, due to frequent adverse terms of trade.

As indicated above, subsequent papers focused on the question of what factors are associated with growth accelerations that are sustained. For example, Berg, Ostry, & Zettelmeyer (2012) identify structural breaks in economic growth in 140 countries and use these to define "growth spells" (periods of high growth preceded by an upbreak and ending either with a down break or with the end of the sample). Their findings show that growth spells tend to be shorter in African and Latin American countries than elsewhere. Further, growth duration is positively associated with the degree of equality in income distribution, democratic institutions, and export orientation. higher propensities to export manufacturers, greater openness to FDI, avoidance of exchange rate overvaluation, and macroeconomic stability. In a similar approach to Jerzmanowsk (2006), Kerekes (2012) interprets growth performance as a Markov switching process with countries switching between four distinct growth regimes (crisis, stagnation, stable growth, and miracle growth). Extending the Markov switching model to account for the distinct dynamics, he assigns countries exhibiting similar dynamics to three clusters (successful, moderately successful and failing countries). His results suggest that securing a minimum amount of human capital can help developing countries avoid falling into the growth failure cluster. In contrast, reasonable-quality institutions are the most distinguishing feature of the countries in the successful growth cluster.

In the context of SSA, the paper by Arizala et al. (2017) examines the growth performance of sub-Saharan countries since 1960 through the lens of growth turning points (accelerations and decelerations) and periods of sustained growth (growth spells). Their findings show that factors associated with growth accelerations are different from those that need to be in place to sustain growth accelerations. Growth accelerations are triggered by improved external conditions, increased investment, and trade openness, declines in inflation, better fiscal balances, and improvements in the institutional environment. For a country to transition from growth acceleration to sustained growth acceleration, it must have in place responsible fiscal and monetary policies, sound management of public debt, outward-oriented trade policies, reduced market distortions, as well as supportive external environment and stronger democratic institutions. The paper highlights that, overall, determinants of growth accelerations that are sustained in SSA are different from those in the rest of the emerging and developing countries.

Notwithstanding differences between the early and subsequent growth turning points literature with respect to what initiates growth acceleration or what sustains it over a long period, scholars following this strand of research have in common that they all emphasise growth determinants often identified in neoclassical growth literature under the banner of "growth fundamentals". Other factors that are salient in driving growth in developing countries, such as structural transformation (Duarte & Restuccia, 2010; Herrendorf et al., 2014) are neglected or completely ignored. This has led to virulent critics from other scholars who vehemently argue that the focus on maintaining macro stability and improving institutional frameworks is not effective in triggering and sustaining economic growth acceleration (e.g., Nissanke, 2019; Rodrik, 2018, 2014; McMillan, Rodrik, & Sepulveda, 2017).

In his paper "Past, Present, and Future of Economic Growth," Rodrik (2014) identifies six relevant stylized facts about growth and development. Relevant for understanding what makes a growth acceleration to be sustained are, namely, the following: (i) contrary to the central insight of classical trade theory, "economic development goes hand-in-hand with productive diversification"; (ii) "historically, industrialization and manufactured exports have been the most reliable levers for rapid and sustained growth"; (iii) "manufacturing industries are special in that they tend to exhibit unconditional convergence", and this regardless of policies and institutions in place; (v) "the most successful economies have not been the ones with the least State intervention"; that is, "less intervention is not necessarily good for growth performance" (pp. 20-27).

Clearly, the stylized facts identified by Dani Rodrik on growth and development, as well as the findings from Hausmann, Pritchett and Rodrik's (2005) paper on growth accelerations, sharply contrast with the agenda of the growth policies spawned by the "Washington Consensus" (Williamson, 1990), which had been inspired by mainstream neoclassical growth theories. These policies put faith in institutional reforms and place great emphasis on stabilisation policies to keep a country's macro balances in checks, privatisation to reduce state intervention in the economy, and liberalisation to optimize the full potential of free markets (Rodrik, 2005). This scholar notes that, for a decade and a half from 1990, the words "stabilize, liberalize and privatize became the mantra of a generation of technocrats who cut their teeth in the developing world and of the political leaders they counselled" (p.973). However, as Dani Rodrik agrees, the results of these policies were disappointingly surprising in Latin America, Africa, and in former socialist countries that made a transition to market economies and embraced the Washington consensus agenda.

As publicly admitted in the World Bank's (2005) "Economic Growth in the 1990s: Learning from a Decade of Reform", the unexpected results were shocking after 15 years of implementation. Rodrik (2005) identified five hocking surprises as follows: First, transition countries from the Soviet union experienced an unexpectedly deep and protracted collapse in output; second, except for a handful of countries, the majority of SSA countries failed to achieve turning points in their growth trajectories despite significant policy reforms, improvements in the political and external environments, and foreign aid. Third, despite their well-known state-led and protectionist policy regimes, growth performance in Latin America during the 1990s was disappointing compared to 1950-80 period; Fourth, unpredicted financial crises become frequent in Latin America, East Asia, Russia, and Turkey; Finally, in the wake of Brazil's devaluation in January 1999, Argentina's currency board proved unsustainable, and the entire country crashed down in 2002. The central message that came out of "Economic growth in the 1990s", according to the World Bank vice-president who wrote the preface of the book, is that: "there is no unique universal set of rules . . . [W]e need to get away from formulae and the search for elusive 'best practices' . . ." (p. xiii).

2.3.5. Neoclassical models and productivity growth

In the standard Solow model, growth was explained by two key factors—physical capital and (unskilled) labour. Solow recognised that technological change is an important contributing factor to economic growth, but in terms of his model, it was considered an unexplained residual, which falls like manna from heaven. However, owing to the availability of a dataset on internationally comparable GDP levels from the late 1980s, economists came to the realisation that the Solow model suffered from severe omitted variable bias (Mankiw et al., 1995). It leaves a high magnitude of income per capita unexplained when comparing international income differences. Indeed, it was the residual attributed to exogenous technological change that typically accounted for the bulk of the variations in economic growth.

The efforts by economists to account for the residual in the Solow model led to the introduction of endogenous growth models that emphasise technological change as the main source of productivity and sustained growth. Different models emphasised varied factors as driving technological change and productivity growth, including innovative physical capital that contributes to technological progress (Frankel, 1962), endogenously determined savings rate, Cass1965). accumulation of intellectual capital such as intangible knowledge (Romer, 1986), externalities and spillovers stemming from human capital (Lucas, 1988), quality-improving innovations (Grossman and Helpman (1991), Aghion and Howitt (1992). Yet, other endogenous-based growth models emphasise the role of policies and institutions that affect the efficiency of investment and human caîtal in supporting or inhibiting productivity growth (Bassanini et al. 2001, Acemoglu et al. 2005).

While the mainstream research had long focused on technological progress as the only source of productivity growth, a new wave of studies referred to as " second wave of productivity analysis" has over the last two decades increased scholars' understanding of the underlying mechanisms and dynamisms of productivity growth (Cusolito and Maloney 2018). Based on firm level data, these studies decompose the sources of productivity growth at the firm level in three components: (i)the within component, which accounts for the productivity growth within firms and depends on changes in the efficiency and intensity with which inputs are used in pro duction; (ii) the between component, which reflects the role of factor reallocation across firms in aggregate productivity growth; (iii).the selection component, which accounts for the gains arising from the entry of high-productivity firms (relative to the industry average) and the exit of low-productivity firms (relative to the industry average (Caldreon, 2022, citing Cusolito and Maloney 2018). This is a revolution compared to the neoclassical growth models which completely ignore resources reallocation as source of productivity growth.

In their book, " Productivity Revisited; Shifting Paradigms in Policy and Analysis," Cusolito and Maloney (2018) confirmed that productivity accounts for half of differences in GDP per capita across countries, highlighting its importance for sustaining growth, alleviating poverty, and fulfilling the rising aspirations of citizens. Yet, the authors lament about the global decline in productivity over the recent decades, particularly in developing countries, which constitutes a major barrier to sustained growth and convergence to advanced economy levels of income.

2.3.6. Neoclassical growth empirics in sub-Saharan Africa

In the last decades, the patterns of growth in Africa have become a principal focus of empirical research and policy analysis for many economists. We identify two generations of empirical literature on growth in Africa. The first generation attempts to explain Africa's growth performance by investigating the determinants of growth over time and across countries using cross-country models and comparative case studies (e.g. Barro, 1991; 2003; Easterly & Leveine, 1997; Sachs & Warmer, 1997; Collier and Gunning, 1999; O'Connell and Ndulu 2000; Acemoglu et al. 2001; Ndulu et al. 2007). The second-generation approaches Africa's growth performance from the perspective of growth turning points and investigate the determinants of growth accelerations and decelerations episodes (e.g., Arizala et al., 2017: Page, 2008; Tsangades, 2012).

Starting with the seminal paper by Barro (1991), the author used the then recent theories of economic growth as a guide to investigate some empirical regularities about growth, fertility, and investment for 98 countries in the period 1960-85. In one of the regressions, in addition to other relevant growth determinants, he included dummies for Africa and Latin America to test a common view that countries in these two continents have poorer growth performances than other countries. A priori, he noted that if the nature of being in Africa or Latin America is already held constant by the other explanator variables, continent dummies would be insignificant in equations for growth, fertility, or investment. As it turned out, the findings from the regression show that the coefficients associated with the dummies were significantly negative, indicating that some regularities are missing from the model.

Barro underscored that the results leave unexplained a good deal of the weak growth performances of countries in sub-Saharan Africa and Latin America. In other words, the analysis does not isolate the fundamental characteristics of the typical country on these continents that lead to below-average economic growth. Some subsequent studies also found that a significant Africa dummy remained (e.g. Barro & Lee, 1993; Easterly & Levine, 1997) despite the various environment and institutional related variables included: “Africa was growing inexplicably slowly” (Collier & Qunning, 1999, p.2). Others eliminate it (Sachs & Warner, 1997; Collier and Gunning, 1997; Temple, 1998), though to an extent by transferring the puzzle elsewhere as in Sachs and Warner (1997) who find a significant ‘tropics’ dummy.

Following Rarro (1991), the World Bank produced two research reports, “Adjustment in Africa: Reforms, Results, and the Road Ahead” (World Bank, 1 994a) and “Adjustment in Africa: Lessons from Country Cases (Husain & Faruquee, 1994), that examine the linkages between policy reforms and economic performance over the past decade. These rigorous country-studies identified a diverse set of potential causes of SSA's poor growth performance, including bad policies, poor education, political instability, inadequate infrastructure, ethnic strife, etc.

In their paper, “Africa’s Growth Tragedy,” Easterly and Levine (1997) Easterly and Levine use cross-country regression model to account for Suh-Saharan slow growth. Performance over the last 30years from 1960. They statistically quantify the relationship between long-run growth and a wider array of factors to improve over past attempts to account for SSA’s growth experience. They find that: (i) low school attainment, political instability, poorly developed financial systems, large black market exchange rate premia, large government deficits, and inadequate infrastructure are associated with slow growth; (ii) Africa's ethnic diversity tends to slow growth and reduce the likelihood of adopting good policies.

Sachs and Warner (1997)’s paper offers some econometric evidence on the sources of slow growth in SSA during the period 1965-90, based on a cross-country regression model developed in Sachs and Warner (1995a, 1995b, 1997). These scholars note that back in 1965, GDP per capita in SSA was 60% of the average of the rest of the developing world. By 1990, this figure had fallen to 35%. The regression results suggest that the continent's slow growth can be explained in an international cross-country framework, without the need to invoke a special explanation unique to SSSA. They find that poor economic policies have played an especially key role in the slow growth, most importantly Africa's lack of openness to international markets. This deprived SSA countries of the vehicle for the importation of technical innovations, which is essential for greater efficiency in the allocation of the economy's scarce resources and market competition. In addition, the results show that geographical factors such as lack of access to the sea and tropical climate have also contributed to Africa's slow growth. These scholars recognize that Africa's colonial legacy, ethnic divisions are also important; they may help to explain Africa's poor choices of economic policy, which account for much of the growth shortfall. Further, and more importantly, the results confirm evidence of resource curse (Sachs & Warmer, 1995) in SSA:

An increase in the initial share of natural resource exports in GDP from 0.1 to 0.2 (10 to 20%) is predicted to reduce subsequent growth by 0.33 percentage points per annum. This result is also confirmed in nine of ten empirical studies focused on Africa and published in leading journals during the 2014-2022 period (see summary by Alssadek & Benhin, 2023). Sachs and Warner recognize that Africa's colonial legacy, ethnic divisions are also important as they may help to explain Africa's poor choices of economic policy, which account for much of the growth shortfall.

In their paper, "Explaining African Economic Performance," Collier and Cunning (1999) review and interpret the aggregate-level and microeconomic literatures to identify the key explanations for Africa's slow growth and massive exodus of capital. They find that there is a reasonable correspondence of the evidence from the regression-based aggregative approach and the case studies and microeconomic research. They pinpoint four factors as being important. a lack of openness to international trade; a high-risk environment; a low level of social capital; and poor infrastructure. They argue that African governments have behaved in ways which are damaging to the long-term interests of most of their populations. "They have been damaging partly through 'sins of commission,' such as agricultural taxation, and partly through 'sins of omission,' such as a failure to provide adequate infrastructure (p.5).

Acemoglu et al. (2001) empirically investigated the effect of institutions on economic performance. They exploit differences in mortality rates faced by soldiers, bishops, and sailors in the colonies in the 17th, 18th, and 19th centuries as an instrument for current institutions. Their main argument is that different colonisation policies and associated institutions were adopted by Europeans in different colonies depending, to a greater extent, on whether they could settle in or not. In places where they faced high mortality rates, they could not settle and they were more likely to set up worse (extractive institutions), which persist to the present. With a strategy of exploitation in mind, European powers had little incentive to invest in institutions or in infrastructure in Africa, despite remarkably high rates of return, except from South Africa. Using the instrumental variable method, they obtain estimates suggesting that over three-quarters of the income per capita differences across countries is due to differences in institutions. The addition of dummies for different continents (Africa, America, and Asia) does not change the estimated effect of institutions, and the dummies are jointly insignificant at the 5 percent level. For Acemoglu and co-authors, the fact that the African dummy is insignificant suggests that the reason why African countries are poorer is not due to cultural or geographic factors, but mostly accounted for by the existence of worse institutions in Africa.

In Barro (2003), the author applied panel data model covering 98 countries from 1965-95 to identify determinants of real per capita GDP growth rates. He identified a group of 20 countries with the lowest per capita growth rates from 1965 to 1995 of which an astonishing 18 countries in sub-Saharan Africa[12] and two in Latin America (Nicaragua and Bolivia). The regression results reveal that model fits poorly the growth experiences of SSA countries. For example, for a country such as the DR Congo (former Zaire), the actual growth was – 0.055 against a fitted growth rate of – 0.021 for the 1975-85 period; these values were 0.088 and 0.049 respectively for the 1985-1995 period. This means that, on average for the 1975-95 period, the model leaves 52 percent of the variations in growth rates unexplained. The country had very favourable convergence effect as predicted by the neoclassical growth model because of its low initial value of per capita GDP. However, this force was more than offset by unfavourable values of most of the other explanatory variables: low life expectancy, low democracy, weak rule of law, low investment, and high inflation.

Following the unprecedent growth acceleration in SSA from the mid-1995, the growth research renewed interest in Africa. For example, ss part of the publication series by the Commission on Growth and Development established in 2006 to take stock of the state of theoretical and

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empirical knowledge on economic growth, Page (2009)'s paper focused on Africa. He analyses growth accelerations and decelerations—that is, country- level deviations from long-run trend growth. Under this perspective, he sees Africa's experience of slow and volatile growth as reflecting a pattern of offsetting accelerations and declines. He looks for correlates associated with acceleration and deceleration episodes and examine the probability that an economy will undergo a growth acceleration or deceleration. He concludes that the reduction in economic declines since 1995 is due both to better policies and some luck, but changes in such "growth fundamentals" as savings, investment, export diversification, and productivity have not accompanied the growth boom. He emphasised that! "Although there has been some improvement in economic fundamentals since 1995, it is not large enough—particularly in comparison with levels found in rapidly growing economies—to support complacency with respect to the durability of Africa's growth recovery"(p.11). For page, lack of substantial change in these traditional growth determinants —and the significant role played by natural resources in sparking growth accelerations— suggest that Africa's growth recovery was fragile, even before the 2008-2009 global financial economic crisis. For him, to sustained growth in Africa would require managing natural resource rents well, pushing nontraditional exports, building the African private sector, and creating new skills.

Similarly, in "Determinants of Growth Spells: is Africa Different?", Tsangarides (2012) investigates the question whether " growth spells in Africa end because of bad realizations of the same factors that influence growth spells in the rest of the world, or because of different factors altogether". He defines growth spells as " periods of sustained growth episodes between growth accelerations and decelerations." He examines determinants of growth spells in Africa and the rest of the world using Bayesian Model Averaging techniques for proportional hazards models, relating the probability that a growth spell ends to various determinants including exogenous shocks, physical and human capital, macroeconomic policy, and sociopolitical factors. The finding from his analysis suggest that determinants of growth spells in Africa are different from those in the rest of the world - initial income, terms of trade, exchange rate undervaluation and inflation influence spells only in the world sample, while increased openness and droughts have a distinct impact in the Africa sample only, and are negatively related to growth spell duration. Additionally, in both Africa and the rest of the world, physical and human capital, and changes in the U.S. interest rate are robustly correlated with growth spells, but estimated marginal effects and hazard ratios vary between the two samples. The effect of investment and an additional year of education in Africa increases the probability of a growth spell will be sustained more than in the rest of the world. changes in the U.S. interest rate have a larder negative effect on growth spells in the non-Africa sample compared to the Africa one.

In the same vein, Arizala et al. (2017) reaches the same conclusion that, overall, determinants of growth spells in SSA are different from those in the rest of the emerging and developing countries. This paper examines the growth performance of sub-Saharan African countries since 1960 through the lens of growth turning points (accelerations and decelerations) and periods of sustained growth (growth spells). Their findings show that growth accelerations are generally associated with improved external conditions, increased investment and trade openness, declines in inflation, better fiscal balances, and improvements in the institutional environment .For a typical country in SSA to transition from growth accelerations to growth spells often requires additional efforts beyond what is needed to trigger an acceleration. Growth spells are sustained by sound fiscal responsible public debt management, monetary policy geared toward low inflation ,trade openness policies, structural policies that reduce market distortions, as well as supportive external environment and improvements in democratic institutions. In terms of policy implications, the authors of the paper underscore that, “ for countries where growth has slowed down, the priority is to maintain macroeconomic stability and set the stage for a growth turnaround that can then be sustained” (p. 6).

More recent studies on growth performance in SSA have turned their focus on the productivity growth in the region as a potential explanation for lack of sustained growth. For example, in a volume published as part of the World Bank flagship research project on productivity, Calderon (2022) synthetise a number of papers that use firm-level data and report evidence of very low (level and growth) productivity in SSA relative to the United States, the EAP5 and other emerging economies. The data show that he (population-weighted) average output per worker in SSA relative to that of the United States declined from 11.9 percent in 1960 to 7.7 percent in 2017, reflecting both exceptionally low labour and stagnant productivity in the region over the past five decades. During the same period, the EAP5 made headway against the global efficiency frontier, climbing from 8.5 percent relative to the United States in 1960 to 29.8 percent in 2017. SSA lost its productivity edge over the EAP5 and other countries in the developing world such as Brazil, China, and India. The study documents that during the 1960s, workers in SSA were, on average, about 40–45 percent more productive than those in the EAP5. By the 2010s, EAP5 were ahead with workers being more than three times as productive as those in SSA. While labour productivity in SSA was double that of China and India in 1960, and slightly lower than Brazil's, by 2017, labour in India was nearly twice as productive, China more than 2.5-fold, and Brazil more than 3 times that of SSA.

The papers synthetised the above volume concur on their conclusion that resource misallocation is the main explanation of low productivity in SSA. They argue that inefficiencies in resource reallocation are the outcome of distortions induced by policies and institutions (including social norms) that prevail in SSA. The focus on policies and institutions as responsible for distortions which create misallocation of resources (including capital, labour and land) resonate with early models based on endogenous growth theory and which allow for the efficiency of investment and human capital in the economy to be influenced by policies and institutional settings (Bassanini et al. 2001, p. 6; Acemoglu et al. 2005). For Acemoglu and Co-authors, institutions are critical in determining the types of incentives which have a positive impact on economic growth, or the disincentives which negatively affect growth rates.

2.4. STRUCTURAL ECONOMICS PARADIGM

2.4.1. Concept of structural transformation

The concept of structural transformation dates to the seminal contributions of development economics pioneers like Clark (1940), Fisher (1939), or Fourastie (1949) in the first half of the 20th century. Clark and Fisher studied economy-wide phenomena, and their contributions dealt with sectoral shifts in the composition of the labour force. Their results stressed the primary-secondary-tertiary shift in industrial structure accompanying economic growth. Syrquin (1988) recognises that Fisher and Clark were the first to deal with the process of reallocation during the epoch of modern economic growth and to use the form of sectoral division (primary-secondary) which, in one way or another, is still with us today. He highlights that although Clark's approach was empirical, "in his subsequent attempts to account for the transformation in the structure of production, he did relate the observed shifts to differential productivity growth and Engel effects, the two principal elements" (p.213).

Subsequent theories of development in the 1950s also stressed sectoral differences as underpinning the process of structural transformation. In his celebrated article (1954), Lewis formalised the ideas developed by Clark and Fisher and presented a two-sector model that draws a sharp distinction between the traditional (agriculture) and modern (industry) sectors of the economy. Lewis investigates the expansion of the industrial sector and demonstrates that the reallocation of surplus agricultural workers, whose contribution to output may have been negligible, to industries where they become productive members of the labour force leads to economy-wide growth.

The use of data in empirical studies of long-term transformation started with the work of Simon Kuznets, who published a series of articles in the "Journal of Economic Development and Cultural Change." The collection of these articles culminated in the publication of his famous book titled "Modern Economic Growth: Rate, Structure and Spread" (Kuznets, 1966). Unlike the then-prevailing practice, Kuznets (1966) relied on historical time series and provided evidence of the unusually high rates of output growth and similar shifts in resource allocation common to all countries undergoing economic development. He sees "modern economic growth" as a new economic epoch, pointing to the unprecedented high rates of growth and shifts in resource allocation as evidence. In his 1971 Nobel Prize lecture, Kuznets (1971) refers to "structural transformation" as one of the six key features of "modern economic growth", which he describes as "the sustained increase in productivity and living standards". He emphasises that major aspects of structural transformation include (i) "a shift away from agriculture to non-agricultural activities and, subsequently, away from industry to services"; (ii) "a change in the scale of productive unit"; and (iii) "a related shift from personal enterprise to impersonal organization of economic firms, with a corresponding change in the occupational status of labour" (Kuznets, 1971, p.2).

The concept of structural transformation is also defined in more recent economic literature as "the reallocation of economic activity across three broad sectors (agriculture, manufacturing, and services) that accompanies the process of modern economic growth" (Duarte & Restuccia, 2010; p.130; Herrendorf et al., 2014, p.2752). It refers to a process many countries undergo along their modern paths of development; this process is characterised by "the birth and expansion of new (higher-productivity) industries and the transfer of labour from traditional or lower-productivity activities to modern ones" (Rodrik, 2014, p.8). In most countries, "this process is characterized by a systematic fall over time in the share of labour allocated to agriculture, by a steady increase in the share of labour in services, and by a hump-shaped pattern for the share of labour in manufacturing" (Duarte & Restuccia, p.134).

While the dynamic of structural transformation in the growth process had been neglected up until recently, there has been a revival of interest in structural dualism and the role of structural transformation. Several papers have emphasised the structural dualism of developing economies and the large productivity gaps between different sectors of the economy (Diao et al., 2019; Gollin, Lagakos & Waugh, 2014; McMillan & Rodrik, 2011; McMillan, Rodrik, & Verduzco, 2014; McMillan & Headey, 2014;). These scholars view the productivity gaps between and within sectors as indicative of the allocative inefficiencies that reduce overall labour productivity. However, they point out that "the upside of these allocative inefficiencies is that they can potentially be an important engine of growth" (McMillan & Rodrik 2011, p.1) and consequently call for government interventions to remove the inefficiencies. They show that when labour and other resources move out of less productive into more productive sectors, overall economy grows even if their productivity growth *within* sectors remain unchanged.

2.4.2. Convergence in Structuralism Approach

In the context of the neoclassical models reviewed in previous sections, all the empirical studies provide no empirical evidence supporting the finding of unconditional convergence when a broad and diversified sample of countries is considered. The only exception is for groups of countries that have similar structural variables (e.g., Barro et al. 1991; Barro, 2012; Barro & Sala-I-Martin; 1992; Mankiw et al. 1992; Sala-i-Martin; 1996). The absence of evidence of unconditional convergence for a cross-section of countries that includes developing countries has prompted researchers to focus on theories of conditional convergence at industry or sectoral levels (see e.g., Rodrik, 2013b; Inklaar, 2014; Assuncão et al., 2015; Kinfemichael & Morshed, 2019). These scholars provide empirical evidence on how unconditional convergence is achieved in structural dualism models.

In his paper, "*Unconditional Convergence in Manufacturing*", Rodrik (2013b) uses data from UNIDO's INDSTAT2 and INDSTAT4 databases, which provide industrial statistics for a wide range of countries at various levels of disaggregation (citing UNIDO 2011, 2012). These statistics cover value added and employment, among others, for up to 23 manufacturing industries per country, allowing the calculation of labour productivity (value added per employee) and its growth at that level of disaggregation. Rodrik provides empirical evidence indicating that "unconditional convergence is alive and well." However, this convergence occurs only in the modern parts of the economy rather than the economy. In particular, he documents a highly robust tendency toward convergence in labour productivity in manufacturing activities, highlighting that this convergence occurs regardless of geography, policies, or other country-level characteristics. The coefficient of unconditional convergence (beta) is large—2.9% a year in his baseline specification that covers 118 countries—implying that industries that are, say, a tenth of the way to the technology frontier (roughly the bottom 20% of the industries in the sample) experience a convergence boost in their labour productivity growth of 6.7 percentage points per annum (0.029xln(10)). The paper emphasises that "this result is general, regardless of the region; in particular, the twenty or so African countries which are represented in the UNIDO data set follow the same pattern as the rest of the world. This result is supported by Inklaar (2014) who finds that convergence was strongest in manufacturing and other goods-producing industries, weaker in services, and weakest in agriculture.

Other scholars have shown that unconditional convergence is not limited to the manufacturing sector, as stressed by Rodrik (2013). Given the increased international trade in services and intense competition within the service sector from firms both at home and abroad, Kinfemichael and Morshed (2019) investigate using disaggregated data whether the service sector, like manufacturing, exhibits unconditional convergence. They use sub-sector-level disaggregated data based on the International Standard Industry Classification (ISIC), using ISIC revision 2 and ISIC revision 3 classifications of the service sector for a large number of countries. Their main result is based on 101 countries, representing 12 sub-sectors of the service sector during the 1971–2012 period. Following the estimation technique suggested by Rodrik (2013), they find a robust and highly significant unconditional convergence for the service sector as well as for some individual sub-sectors. Their findings suggest that countries starting with conditions of low initial labour productivity in the service sector grow faster than countries with higher initial labour productivity in that sector.

Given the finding of unconditional convergence in the service sector, while Rodrik (2013) found the same for the manufacturing sector, a puzzling phenomenon has been the failure of the economies to exhibit unconditional convergence despite the strong pull of convergence within the service and manufacturing industries. Rodrik (2013b) addresses this issue and concludes that aggregate non-convergence appears to be explained by the following combination of facts: (i) non-manufacturing activities do not exhibit unconditional convergence; (ii) poor countries have little employment in manufacturing, depressing the contribution of manufacturing to overall growth; (iii) the share of employment in manufacturing rises over the course of development, giving less-poor countries a growth boost; and (4) the reallocation effect is neither sizable enough nor systematically larger at lower income levels. Kinfemichael and Morshed (2019) argue that the lack of convergence in the aggregate per capita GDP should not be attributed to the small share occupied by the manufacturing sector in the economies of poor countries, as suggested by Rodrik. For these authors, Rodrik's division of economies into manufacturing and nonmanufacturing sectors combines the agriculture sector with the service sector as "nonmanufacturing" sectors. However, based on their findings, there is a large and growing service sector within this "nonmanufacturing" sector classification in which they also find unconditional convergence. Consequently, they conclude that the lack of unconditional convergence in per capita GDP is not because the manufacturing sector is small in poor countries. In order to reconcile the presence of unconditional convergence in the manufacturing and service sectors with the non-convergence of aggregate output per capita, they suggest that "it is necessary to examine a number of factors, including trends in agricultural labour productivity, "aggregation bias," and the relationship between output per capita and output per worker"(p.31).

For Rodrik (2018), considering the convergence theory in the neoclassical models, the finding of unconditional convergence in manufacturing and modern service sectors is a remarkable result. What is surprising is the fact that these sectors converge to the global productivity frontier regardless of whether a country has strong or weak fundamentals (geographical disadvantages, lousy institutions, or bad policies). As he put it, "What is striking is the presence of convergence, in at least certain parts of the economy, even in the absence of good fundamentals" (p.15). This, however, he admitted, does not mean that the speed of convergence towards the productivity frontier is the same across countries. This point is supported by Assuncão et al. (2015) - who use the same data set as Rodrik (2013) to investigate whether unobserved heterogeneity in the convergence coefficient at the country level is associated with geographic conditions, trade openness, political institutions, and education. Their findings show that the speed with which countries converge to their steady state is different across countries. Countries with]with quality political institutions converge faster; less democratic states grow at higher paces, a result that is compatible with those documented in Barro (1996, 1999). Moreover, the speed of convergence also has a non-monotonic relationship with trade openness and education, suggesting faster convergence at the extremes.

The key insight from the studies based on industry-level", conclude Rodrik (2013) is that "lack of convergence is due not so much to economy-wide fundamentals or endogenous technological change but to specific circumstances that influence the speed of structural reallocation from non-convergence to convergence activities" (p.202). For this scholar, the policies that matter are those that aim at supporting directly this process of reallocation. Rodrik emphasises that "what high-growth countries typically have in common is their ability to deploy policies that compensate for market and government failures that block growth-enhancing structural transformation. Countries that manage to affect the requisite structural change grow rapidly, and those that fail don't" (pp.203-204).

2.4.3. Patterns of Structural Transformation and Growth Empirics for Africa

The key role of structural transformation in driving economic growth and productivity improvements has been empirically supported by previous influential studies in both developed countries (see e.g., Caselli & Coleman, 2001; Denison, 1967; van Ark & Timmer, 2003) and developing economies (Fan et al., 2003; Vu, 2017). These studies find that structural transformation has contributed to growth significantly by reallocating resources from low-productivity to high-productivity sectors, underlying the importance of reforms to remove inefficiencies and foster productivity-enhancing structural transformation.

Some studies, however, have found that structural transformation may have a negative effect on overall economy's productivity growth (Baumol, 1967; Baumol et al., 1985 as cited by Vu, 2017) or "can be a by-product of economic growth and may have no feedback effect on the growth process" (Meckl, 2002 as cited in Vu, 2017, p.67). Yet some others also found that it might not show up in aggregate growth (Ngai & Pissandes, 2007, as cited in cited in Vu, 2017). These results have led researchers in recent years to focus on the nature and patterns of structural transformation in developing countries (see, e.g., Diao et al., 2019; Diao, Ellis, et al., 2021; Inter-American Development Bank (IADB), 2010; McMillan & Rodrik, 2011; McMillan, Rodrik, & Verduzco-Gallo, 2014; McMillan & Harttgen, 2014; McMillan et al., 2017; McMillan & Zeufack, 2022; Mensah et al., 2023; Timmer et al., 2015a, 2015b). These studies find that different patterns emerge in different regions and countries, with different contributions of structural transformation to productivity growth.

The key step in empirically analysing the contribution of structural transformation to productivity growth is how to measure structural transformation. Researchers usually followed McMillan & Rodrik's (2011) unifying framework, which acknowledges that a "complete accounting of labour productivity growth must take into account the fact that labour productivity growth can be achieved in one of two ways" (Diao et al., 2019, pp.296-297). First, it is acknowledged that "productivity can grow within existing economic activities through capital accumulation or technological change." Second, "labour can move from low-productivity to high-productivity activities, increasing overall labour productivity in the economy." To determine the contributions of sectoral productivity growth to economy-wide productivity growth, researchers have relied on a decomposition used in McMillan & Rodrik (2011)[13].

According to Diao et al. (2019, p.297), the change in aggregate productivity in each period can be decomposed into two or three terms, depending on the level of analysis undertaken. The first, known as the "*within term,*" captures how much of the change in aggregate productivity can be explained by the change in productivity within each sector (multiplied by the share of employment in each sector at the beginning of the period). The second term, known as the "*between term or structural transformation,*" captures the change in productivity associated with the reallocation of employment from low productivity to high productivity sectors (measured as the sum of the changes in the employment share multiplied by the initial level of productivity in each sector). "The last term, known as the *cross term*, is an accounting term that reconciles growth in the aggregate with the *within* and *between* terms; it captures whether labour is reallocated to sectors that are growing in productivity" (Timmer et al., 2015b, p.16).

Using this decomposition method in the study of low productivity in the Latin America region and using data from the database produced by the Groningen Growth and Development Centre (GGDC) for nine Latin American economies for the 1950–2005 period, the IADB (2010) finds that the contribution of the different components of productivity growth has been uneven over the different periods. During the high-growth period of the 1950s and 1960s, growth was driven by large within-sector gains but also, quite importantly, by large gains driven by the reallocation of workers from less productive sectors to more productive sectors (*between*

[13]McMillan and Rodrik (2011) adopted a decomposition used in previous papers to explore the contributions of the reallocation of activity across plants and plant productivity growth to overall productivity growth in the US manufacturing (citing Haltiwanger, 1997; Foster, Haltiwanger, & Krizan, 2001).

sectors). In contrast, during the lost decade of the 1980s, negative aggregate labour productivity gains were driven mostly by negative gains in productivity *within* most sectors, although this undesirable pattern was partly compensated by positive gains associated with reallocation across sectors.

In the mid-1990s and early 200s when aggregate labour productivity growth resumed, it was again driven by *within*-sector productivity growth. The study finds that a significant difference relative to the earlier period was the insignificant role played by reallocation across sectors in the latest period, a contribution that accounted for half the productivity growth during the period of higher growth. The study interprets these trends as suggesting that an important engine of growth—structural transformation—during the early years of the sample has ceased to operate. McMillan and Rodrik (2011) were surprised by these findings considering the commonly accepted view that "Latin America's policies and institutions improved significantly as a result of the reforms of the late 1980s and early 1990s" (p. 14). They note that, compared to the macroeconomic populism and protectionist import-substitution policies that had prevailed until the end of the 1970s, this new economic environment was expected to yield significantly enhanced productivity performance.

Another notable study using a similar decomposition to document the patterns of structural transformation and productivity growth in developing economies is the one by McMillan and Rodrik (2011). Their data cover the period from 1990 up to 2005 and consist of sectoral and aggregate labour productivity statistics for 38 countries included in the GGDC, comprising nine African countries, nine Latin American countries, ten developing Asian countries, one Middle Eastern country, and nine high-income countries. Overall, the study's findings demonstrate that "there are large differences in patterns of structural change across countries and regions and that these account for the bulk of the differential performance between successful and unsuccessful countries" (p.12). They show that while Asian countries have tended to experience productivity-enhancing structural change, both Latin America and Africa have experienced productivity-reducing structural change. In a recent update, McMillan, Rodrik, & Verduzco-Gallo (2014) identified three factors that determine the extent to which structural transformation is growth-reducing or growth-enhancing. Relevant to this study is their finding that "economies with revealed comparative advantages in primary products are at a disadvantage. The larger the share of natural resources in exports, the smaller the scope for productivity-enhancing structural change" (p.12). They argue that, unlike manufacturing industries and services, "minerals and natural resources do not generate much employment" (p.12).

Turning to structural change by region, McMillan & Rodrik (2011) show that structural transformation has made insignificant contribution (positive or negative) to the overall growth in labour productivity in the high-income countries in the sample. Their results suggest that, to a larger extent, a significant driver of economy-wide performance in these economies is the growth in productivity within individual sectors. For the developing countries, on the contrary, their results indicate that structural transformation has had an important effect on growth in all three regions, but with strikingly sharp differences among the regions. In both Latin America and Africa, structural transformation has negatively contributed to overall growth, while Asia is the only region where structural transformation has been growth-enhancing. Productivity growth within individual sectors has been broadly similar across all developing regions. The study emphasized that the difference in growth performance between Asia and the two other regions is in the patterns of structural transformation. Asia has been successful in ensuring that the broad pattern of structural transformation contributes to, rather than detracts from, overall economic growth. The authors view these findings as puzzling, especially for Africa, considering the important sectoral productivity gaps that exist and the reforms that African countries have undergone since the late 1980s.

In McMillan & Harttgen (2014), the authors find that the results for Africa are heterogeneous depending on the time-period under consideration. For the 1990–2005 period, the results indicate that structural change has been growth-reducing on average in Africa, although with important exceptions. From 2000 onward, structural transformation was found to have contributed positively to Africa's overall growth, accounting for nearly half of it (see also Busse et al. 2019; McMillan & Headey, 2014). The findings also show that in over half of the countries in their Africa sample, structural change coincided with an expansion of the manufacturing sector (albeit small), "indicating that these economies may be becoming less vulnerable to commodity price shocks" (p. 24).

A more recent update by Diao et al. (2019) uses the GGDC data (last revised in 2015) for the analysis. Their findings provide interesting insights. First, while labour productivity growth was low or negative prior to the recent growth acceleration, it was much higher during growth acceleration periods in all regions. Second, while both the within-sector and structural-transformation components of labour productivity growth were negative prior to the growth in acceleration in Africa, structural transformation contributed modestly to labour productivity growth in Latin America, but with negative labour productivity growth in the non-agricultural sector. Third, after the growth acceleration, structural transformation made a significant positive contribution to growth in Africa, with a smaller contribution of within-sector labour productivity growth in the non-agricultural sector than in agriculture. Fourth, structural transformation made a minimal contribution to growth in Latin America during the period of rapid growth, implying that “labour has moved from more productive subsectors to less productive subsectors within non-agricultural sectors.” Fifth, “recent growth accelerations were based on either rapid within-sector labour productivity growth (Latin America) or growth-increasing structural change (Africa), but rarely at the same time” (p.306). The authors emphasise that “this pattern contrasts with the Asian growth experience in which both within-sector labour productivity growth and structural change contributed strongly positively to aggregate labour productivity growth” (p.306). These findings have been subsequently confirmed (e.g., Diao, Ellis et al., 2021; McMillan & Rodrik, 2021; McMillan & Zeufack, 2022; Mensah et al., 2023).

In “Africa’s Manufacturing Puzzle,” Diao et al. (2021) draws on evidence from Ethiopian and Tanzanian firms to shed light on puzzling patterns of structural transformation during the growth acceleration period. These patterns are characterized by increasing productivity in agriculture, a declining share of the labour force employed in agriculture and declining productivity in modern sectors such as manufacturing. Their analysis disaggregates firms in the manufacturing sector by size using two newly created panels of manufacturing firms covering 2008-2016 for Tanzania and 1996-2017 for Ethiopia. The results of the analysis reveal a dichotomy between larger firms, which record superior productivity performance but do not expand employment much, and small firms which absorb employment but do not experience any productivity growth. Diao and co-authors interpret these results as suggesting that the poor employment performance of large firms is related to use of capital-intensive techniques associated with global trends in technology.

Similarly, drawing heavily on the results in Diao et al. (2021), McMillan and Zeufeck (2022) examine recent patterns in labor productivity growth and industrialization in Africa. They recognise some encouraging signs of I nascent industrialisation in Africa, with manufacturing employment on the rising trend at a rapid pace since 2000. Their analysis identifies three emerging striking patterns. First, there has been a rapid increase in the number of African manufacturing enterprises with less than ten employees, referred to by the authors as “small” and “informal” firms, where the employment share is on increase in contrast to Asian trend. Second, Africa’s large manufacturing firms are productive; however, employment growth in these firms has not been rapid enough to decrease the share of small firm employment in total manufacturing employment. “ There is a concern that manufacturing is becoming more capital-intensive, and thus may not be as powerful a direct creator of jobs as in the past” (pp. 28-29). Third, labor productivity growth in Africa’s manufacturing sector is accounted for by structural transformation; the “within-sector” labour productivity growth in manufacturing is close to zero.

Finally, and in the same vein, Mensah et al. (2023)’s paper uses the Groningen’s Extended Africa Sector Database and presents a shift-share decomposition of the role of structural transformation in driving labour productivity in SSA. Overall, their analysis shows that productivity growth has been slow, with large and persistent sectoral productivity gaps present. Nonetheless, the extent of structural transformation has been higher than that observed in previous studies. The analysis confirms results from previous studies that find the patterns of structural transformation in Africa is characterised by a declining trend in the share of employment and value added in agriculture, with resources moving into service sectors that have low productivity. As an ultimate, these patterns of constrain improvements in aggregate productivity with the general direction of structural transformation biased towards the least productive sectors, improvements in aggregate productivity are severely constrained.

All together, the findings reported in the above studies on the stylized facts and patterns of structural transformation constitute a shaky ground for the neoclassical-based growth regression literature, which relies on one-sector models. In particular, they confirm the argument made by Temple (2005) that dual economy models may be the most appropriate than the one-sector neoclassical models for studying growth process in developing countries. He stresses that, in developing economies where significant sectoral productivity gaps exit, “the ‘growth bonus’ obtained by reallocating labour to a sector where productivity is higher can represent a large share of economy-wide productivity growth” (Temple, 2005, p.195). As it has turned, owing to second generation productivity analysis based on firm level data, there is now a consensus in the economic literature that reallocation of resources between sectors and units in an economy is also an important source of productivity growth (Calderon, 2022).

However, there is still more to learn about structural dualism and growth in developing countries, particularly in Africa, where structural transformation is of much relevance for thinking about growth and development today. First, it is noy clear from the structural change literature what mechanism channels explain differences in the patterns of structural transformation observed in different countries and region. Identifying such mechanisms is relevant for policy aimed at triggering and accelerating growth-enhancing structural transformation. Second, the few studies that cover Africa rely primarily on the GGDC dataset, which only includes a handful of developing countries, of which eleven are African countries. Although this database has been recently updated (de Vries et al. 2021), it only includes 18 SSA countries and still covers 10 sectors. Some researchers have attempted to extend the Africa sample to include more countries (e.g., McMillan & Harttgen, 2014; Busse et al. 2019); however, they did so at the cost of data reliability or in a manner that is too coarse by defining broad categories such as agriculture and non-agriculture. Further, most studies rely on simple quantitative measures such as sectoral shares of employment and value added to document patterns of structural transformation and assess its contribution to economy-wide productivity. As argued by Hartmann et al. (2017, p.75), "these measures fail to take the sophistication of the products into account, or capture differences in industrial structures in a manner that is too coarse". Furthermore, though these studies provide evidence of weak and growth-reducing patterns of structural transformation in developing countries, they do not provide clear policy implications for affecting the speed and patterns of structural transformation from low-productivity sectors to high-productivity ones.

2.5. CONCLUDING REMARKS AND WAY FORWARD

The review of literature undertaken in this chapter focused on traditional paradigms, which offer different perspectives on key ingredients determining the economic performance of countries and future development. The aim was to seek answers to the main questions at the heart of this PhD research. The review highlighted the strengths and limits of each of these perspectives and showed that both macroeconomic fundamentals-based approaches and structural dualism offer complementary perspectives on economic growth and convergence, while providing distinct reasons why growth should be expected, but also how it can be accelerated and sustained.

The mainstream macroeconomics approach emphasised the role of improving “fundamentals" or determinants of steady state income levels, to achieve higher growth and convergence in poor countries. Most notably, it empirically established the conditional convergence hypothesis and demonstrated that countries improving their fundamentals would be expected to have higher steady state levels of income and a higher rate of growth. In addition to factor accumulation, this approach also emphasised productivity growth stemming from technological progress as a key driver of economic growth and convergence. Efforts to identify the underlying causes of technological progress led to different variants of endogenous growth models, each emphasising different mechanism channels for the emergence of constant or increasing returns to the reproductible factors of production and monotonic increase in growth rates. These models underscore the role of policies and institutions in fostering or inhibiting these mechanisms and determining the growth path of different countries.

While the focus of empirical research in macroeconomic approach to growth remained for long centred on investigating determinants of cross-country differences in average growth rates, the turning points growth literature addressed the questions of growth dynamics within a country like the ones investigated in the present study. However, this literature remains in the neoclassical aggregate modelling of the economy, which ignores or neglects the role of productive structures that have been found to be the harbinger and key determinant of productivity and growth (Hidalgo & Hausmann, 2009; Tacchella et al., 2012; Cristelli et al., 2013). As a result, it is yet to be known whether a change in a country’s productive structure can trigger growth acceleration or contribute to the duration of a growth spell that is sustained for several years.

Most critics of the mainstream neoclassical growth models have come from evolutionary economics theory scholars who are puzzled and saddened that their colleagues in economics continue to hold onto a neoclassical growth theory that cannot deal adequately with an economic context in which innovation is important (see e.g., Elsner et al., 2014; Nelson & Winter, 1982; Lall, 2000; Nelson, 2008; Orhangazi, 2017). These scholars argue that the neoclassical growth theory does not explain what is happening. It is not able to illuminate the key details of growth, qualitative as well as quantitative, that one sees in the accounts of economic historians. Moreover, it does not correctly specify the basic processes of technological learning and innovation that are driving economic growth (Nelson, 2008).

The proponents of structural dualism emphasised the macroeconomic role of productivity-enhancing structural transformation, in particular industrialization, as a powerful engine for growth in poor economies where large productivity gaps exist across heterogeneous sectors. They emphasise that “countries that manage to affect the requisite structural change grow rapidly, and those that fail don’t" (Rodrick, 2013b, pp. 203-204). Nonetheless, it remains unclear what policy levers should be activated to induce patterns of structural change that are growth-sustaining. Structural transformation scholars offer a resignation position, stating that the policies which supported the rise of industrialisation and manufacturing exports in East Asian emerging economies, such as subsidized export programmes and overvalued currency, are no longer feasible in today(s global policy environment.

Owing to what is referred to as “second generation productivity analysis,” which focused on firm-level data, there is now a consensus between macroeconomics-based fundamentals and structuralism approaches as to the main sources of productivity growth: technological change and sectoral resource reallocation. Notwithstanding this conceptual consensus, scholars have pointed out that policies that are designed for ensuring and maintaining sound macroeconomic fundamentals and macroeconomic stability are inadequate for fostering growth-enhancing structural transformation (Nissanke, 2018, Rodrik, 2013b). This has prompted the proposition of macroeconomic frameworks that integrate insights from both perspectives to account for growth faltering and growth accelerations that are sustained for long periods such as those observed in emerging Asia.

Despite advancements in the knowledge of factors driving economic growth – factors accumulation and productivity growth – there is still an important gap in the literature reviewed in the previous sections as to what are the underlying factors or fundamental causes (not proxy) of productivity growth at firm and country levels. Why do some firms and countries develop and adopt more advanced technologies and become more productive while other fail? Why do some countries transform and diversify their economies towards higher productivity sectors while other fail to do so? While proponents of modern structural dualism remain silent on both question, the recent mainstream literature on productivity growth highlights that the “within component” of total productivity growth “ depends on changes in the efficiency and intensity with which inputs are used in production (that is, to upgrade firms) owing to increased firm ***capabilities*** (including improved managerial skills, labor skills, innovation, and technology adoption capacity) (Calderon, 2022, p.6).

By pointing to capabilities as the fundamental source of productivity growth, the mainstream literature joins the evolutionary theory and the strategic management and innovation literature. These strands of literature have for long focused on firms' capabilities not only as the driver of their growth, but more importantly, as the immediate cause of industrial development and countries' wealth (see e.g., Lall, 1992; Sutton, 2002, 2012; Penrose, 1959; Nelson & Winter, 1982; Teece, 2019; Fagerberg & Srholec, 2017; Teece & Pisano, 2003; Sainsbury, 2020). It has also joined the Schumpeterian technological catch-up and innovation literature, which draws on sources of growth in the second generation of endogenous growth and focuses on technological capabilities. Th This strand of literature provides compelling evidence suggesting that the patterns and rates of long-term economic growth are strongly driven by technological upgrading and innovation (Lee et al. 2021, Mohnen & Hall, 2013, Nelson & Winter,1982).

As rightly pointed out by Aistleitner et al. (2021), “even though scholars from various disciplines agree on the relevance of capabilities and have produced various empirical insights on the factors driving capability accumulation (CA), many of these insights from the applied literature specialized on CA have not made their way into macroeconomic models. Neoclassical economics has mostly treated firms as homogeneous black boxes and abstracted from the heterogeneous capabilities that differentiate them and until quite recently, it has not developed the concept of capabilities(nor devoted many efforts to the question of how firms and countries accumulate capabilities (Aistleitner et al.,2021;Teece, 2017). In the meantime, for us to derive relevant policy implications for sustaining economic growth and development, it is crucial to grasp the processes or mechanisms through which capabilities are accumulated.

Zooming on the empirical findings in this literature which are relevant to the questions being investigated in this PhD study, two significant findings need to be further researched. First, a surprising finding from the neoclassical-based fundamentals approach to growth and convergence was that natural resources are a curse for countries that possess them in abundance or depend on them, in that they hinder long-term growth performance. This feature is confirmed by findings from structural transformation literature, which reports evidence suggesting that “the larger the share of natural resources in exports, the smaller the scope for productivity-enhancing structural change” (McMillan & Rodrik, 2011, p.12). These scholars argue that, unlike manufacturing industries and services, “minerals and natural resources do not generate much employment” (p.12). However, while this phenomenon referred to as “ resource curse” has been the focus of research for three decades since the seminal contribution by Sachs and Warner (1995), the evidence is mixed – there is no consensus as to whether natural resources are a curse.

The second finding in the reviewed literature that is worth further research is the finding that productivity (level and growth) remains critically low in SSA, due to inefficiencies in resources reallocation caused by policy and institutions-induced distortions, as well as by awkward patterns of structural transformation. The reviewed literature loosely mentioned firms’ capabilities as being the backbone of their productivity growth, suggesting that these capabilities may be what needs to be fostered to boost productivity in SSA countries. However, given the less attention devoted to capabilities in growth research in SSA, there is a need for further research to understand how capabilities are accumulated and by which mechanism channels they affect productivity and growth. Therefore, to better address the questions at the centre of this study’s investigation, the next two chapters will further explore in depth two significant conceptual frameworks that predict the persistent failure of resource-rich economies to sustain rapid growth. The first is concerned with the resource-curse hypothesis, which perceives natural resources as a hindrance to growth and development (Chapter 2). The second is the economic complexity framework, which emphasises the lack of incentives to accumulate productive capabilities as a major constraint to economic diversification, improved productivity and sustained growth (Chapter 4).

CHAPTER 3
THE NATURAL RESOURCE CURSE HYPOTHESIS

3.1. INTRODUCTION

The role of natural resources in growth and development processes has been puzzling. Since the founding fathers of economics, “there has been a deep belief that countries blessed with natural resources such as oil and gas can base their development on these resources and use them as a key path for sustained economic growth” (Badeeb et al.,2017, p.123). Numerous scholars have pointed out that natural resources—notably coal as a source of energy—were among the primary drivers of the industrial revolution (Mikesell, 1997; Kronenberg, 2004); they also played a prominent role in increasing economic growth in today’s developed countries, for example, in the United States, Australia, Canada, and Scandinavian countries (Stevens, 2003). This view of the positive role of natural resources has long been well summarised by Rostow (1961) who argues that “natural resource endowments would enable developing countries to make the crucial transition from underdevelopment to industrial take-off, just as they had done for countries such as Australia, the United States, and Britain (as quoted by Badeeb et al., 2017, p.124).

However, the positive belief on the effect of natural resources on economic growth started to change in the 1990s, when natural resources came to be viewed more as a "curse" than a "blessing". This follows the publication of several notable studies, including Gelb (1988) and Auty (1993) which unveiled “the tendency of resource-rich countries to experience slower economic growth than resource-poor countries” – a phenomenon referred to as the “natural resource curse”.

Sachs and Warner's (1995a) seminal paper are one of the first significant empirical studies using econometric methods to investigate the effects of natural resources on economic growth. This study laid the foundation for empirical research on what is known as the “resource curse hypothesis” (Sachs & Warner, 1995b, 1997a, 1999, 2001). Studies by other scholars confirmed this phenomenon (Sala-i-Martin, 1997; Gylfason, 2001; Mehlum et al., 2006a; Beck, 2011). By the end of the 1990s, there was a broad agreement among scholars regarding the existence of a “resource curse" in resource-rich countries. In subsequent years, research focused on explaining the transmission mechanisms through which natural resources affect economic growth and development. However, over the years, as more rigorous econometric analyses were conducted using new, more extensive data sets and dynamic panel data models, doubts about the existence of the resource curse hypothesis emerged, with some researchers questioning the very existence of the resource curse (see e.g., Arezki & van der Ploeg, 2007; Brunnschweiler & Bulte, 2008; Di John, 2011; Frankel, 2010; Kaznacheev, 2017; Lederman & Maloney, 2007; Stijns, 2005; van der Ploeg, 2011).

In this chapter, we review and assess theoretical and empirical approaches to resource curse. We begin with different perspectives that offer explanations on how natural resource abundance/dependence adversely affect economic growth and development (Section 2.2). Thereafter, we turn to the examination of selected empirical research papers evaluating the resource curse hypothesis (Section 2,3). Section 2.4. offers some concluding remarks, identifying gaps for further research.

3.2. THEORETICAL APPROACHES TO RESOURCE CURSE

A wide range of scholars from across different scientific disciplines have studied the resource curse over the last three decades. However, little consensus emerges on the theoretical approaches for explaining the inverse relationship between natural resource abundance/dependence and economic growth. A survey of the various theories proposed in the literature broadly indicates that, depending on the transmission channels emphasised, natural resource abundance/dependence negatively affects growth or its long-term determinants through two distinct but overlapping causal mechanisms. These are the economic and political or institutional channels (see e.g., Alssadek & Benhin, 2023; Badeeb et al., 2017; Papyrakis, 2017; Ross, 2015).

3.2.1. Economic-Based Approaches

Theoretical explanations based on economic transmission channels namely emphasise: (i) the effects of "Dutch Disease" (Alssadek & Benhin, 2022; Bahar & Santos 2018; Cherif; 2013; Frankel, 2012; Sachs &Warner, 1995; Stevens & Dietsche, 2008; Torvik, 2001); (ii) the volatility of natural resource prices in the international market (Auty & Mikesell, 1998; Cavalcanti et al., 2011; Davis & Tilton, 2005; Mikesell, 1997; van der Ploeg & Poelhekle, 2009); (iii) limited investment in human capital development (Araji & Mohtadi. 2018; Birdsall

& Pinckney, 2001; Chang and Wei, 2019; Gylfason, 2001; Gylfason & Zoega, 2006; Shao & Yang, 2014; Talvi et al., 2018); and (iv) slower pace of financial development through crowding out effect on investment (Beck, 2011; Bhattacharyya & Hodle, 2014; Dogan et al.2020; Dwumfour & Ntow-Gyamf, 2018; Hussain et al.2020; Kassouri et al, 2020).

3.2.1.1. *Dutch Disease*

One of the most prominent economic mechanisms through which the resource curse may adversely affect growth is what is known as "Dutch Disease", a term coined in 1977 by *The Economist* to describe a phenomenon characterised by the decline of the Dutch manufacturing sector after the discovery of natural gas sources in the North Sea. According to Corden and Neary (1982) and Corden (1984), the Dutch disease results from the resource movement and spending effects following a natural resource boom. They referred to these two effects, respectively, as ‘direct de-industrialisation’ and ‘indirect deindustrialisation,’ and show that they lead to slow growth in the economy.

Humphreys, Sachs, and Stiglitz (2007) summarise well the channel effects involved in the Dutch Disease. A sudden rise in the value of natural resource exports results in large inflows of foreign exchange, which in turn causes an appreciation of the real exchange rate. This can lead to an increase in the relative prices of non-resource commodities, making their exports less competitive relative to world market prices and thus reducing their competitiveness and the investment they attract (called "spending effect"). Meanwhile, when foreign exchange earned from natural resource booms is used to purchase internationally traded goods, this plays at the expense of domestic manufacturers of the goods. Consequently, domestic resources will be moved away from manufacturing to the natural resource sector, which will result in an increase in the price of these resources in the domestic market. As an ultimate result of this chain of reactions and effects, the production costs of other non-resource export sectors such as manufacturing and agriculture increase, leading to output contraction in these sectors. Sachs and Warner (2001) argue that “as a result of these spending and pull effects, if manufacturing sector is the long-term source of growth, then the decline of this sector will have adverse growth consequences” (p.833).

Similarly, Harding and Venables (2016) consider changes in non-resource (manufacturing, agriculture, and service) exports, imports, and the capital account from foreign exchange windfalls such as those from natural resource revenues. They study the balance between these responses and show that the response to $1 of resource revenue is, for their preferred estimates, to decrease non-resource exports by 74 cents and increase imports by 23 cents, implying a negligible effect on foreign savings. The negative per-dollar impact on exports is larger for manufacturers than for other sectors, and particularly large for internationally mobile manufacturing sectors.

Using different assumptions, scholars have developed and proposed frameworks to analyse the growth effect of Dutch disease on growth, often reaching different conclusions. For example, Krugman (1987) presents a model intended to shed light on three widely held views that are puzzling in standard models, namely that "the discovery of exportable natural resources may lead to a permanent loss of other sectors and a decline in growth". His model shows that the effects of Dutch disease depend on the size and duration of the oil boom. Its effect can be long-term or large enough; otherwise, it will be a short-term phenomenon. Bjørnland and Thorsrud (2016) depart from the assumption of an exogenous source of production made by Corden and Neary's (1982) model and assume that there are production spillover effects from the efficient utilisation of the oil sector on other sectors of the economy. For example, they argue that in countries where the oil sector frequently requires technical solutions to improve offshore oil drilling, this might create positive knowledge externalities to support other sectors. If there are strong backward and downward linkages between these sectors and the oil boom sector in the economy, then by virtue of learning-by-doing spillovers, this will result in virtuous effects on the overall economy, and natural resources may in fact be a blessing rather than a curse. This conclusion is more extreme than what had been previously reported in other studies, namely that the Dutch disease might have adverse effects on growth in the long-run if there are delays of learning-by-doing in the competitive manufacturing sector, which is considered a key for growth" (Wijnbergen, 1984; Matsuyama, 1992; Torvik, 2001, as cited by Alssadek & Benhin, 2023). It also contrasts with the prediction of the theoretical framework of the Dutch Disease developed by Bahar and Santos (2018), which suggests that an oil boom increases local expenditure and puts pressure on wages, negatively affecting the competitiveness and volume of exports of the manufacturing sector, particularly in the labour-intensive sector.

Some researchers have reached even more extreme conclusion that the effects of the Dutch disease on the growth dynamics of resource-rich economies were not significant (Kaznacheev, 2017, citing Mikesell; McMahon; & Torvik, 1997). Kaznacheev (2017), argues that "in essence, the Dutch disease is an adjustment to a new economic situation that emerges as a result of increased commodity exports". Such economic adjustments, he pursues, "happen in all open economies, not just in resource-exporting ones, as a reaction to higher returns on both labour and capital in specific industries" (pp.8-9). He also argues that Dutch disease effects are extremely limited in resource-rich economies because there is either a small or non-existent manufacturing sector to start with, such that, by definition, no reallocation can occur. Other scholars have even argued that the Dutch Disease should not be considered "a malady at all", finding no evidence of adverse effects of natural resource export booms on the manufacturing and agriculture sectors of resource-based economies (Alssadek & Benhin, 2023, citing Benjamin, Devarajan, &Weiner, 1989; Davis, 1995; Fardmanesm, 1991).

3.2.1.2. Commodity Prices Volatility

Proponents of this economic channel argue that "the problem is not resource dependence per se, but rather the volatility of mineral commodity prices in the global market" (Cavalcanti et al., 2014; p.859). They argue that volatility reduces economic growth through "boom–bust cycles," in countries that depend heavily on natural resource sectors (Cavalcanti et al., 2014; Davis & Tilton, 2005; Frankel, 2010; van der Ploeg & Poelhekke, 2009, van der Ploeg, 2011). These scholars show that planning for economic development is challenging and ineffective in countries relying on natural resource rents, due to market instability and uncertainty that makes it difficult to anticipate and impose fiscal discipline (Auty, 1998; Davis & Tilton, 2005).

The harmful effects of commodity price volatility have been documented. Mikesell (1997) found that economies with a high proportion of natural resource exports over the two decades between 1972 and 1992 experienced an overall trade volatility three times greater than non-resource economies. Auty (1998) also suggests that revenue volatility may be one of the major causes of economic slowdowns in resource economies. Other studies published later focused specifically on the price volatility effect. Van der Ploeg and Poelhekke (2009) show that commodity price volatility increases liquidity constraints, which is more likely to hamper innovation and lead to faltering growth process. They also argue and present evidence indicating that, in countries that depend heavily on natural resources, per capita output growth depends negatively on the volatility of unanticipated output growth, which in turn is driven by the high volatility of world resource prices. Their findings indicate that countries with a share of natural resource exports to GDP greater than 19% have a standard deviation of output growth of 7.37%. This is significantly higher relative to a standard deviation of only 2.83% for countries with a resource export/GDP ratio of less than 5%.

While it is admitted that “the price volatility hypothesis seems to make somewhat more sense than the Dutch disease hypothesis,” (Kaznatcheev, 2017) expresses scepticism about the validity of the volatility curse hypothesis, arguing that it “suffers from several problems” (pp.10-11). First, he stresses that, as with the Dutch Disease, natural resources are not different from other commodities traded in an open international market; these commodities exhibit some inherent degree of volatility by their very nature or indeed by the nature of any prices in a free market. Nonetheless, he pointed out that, besides natural resources, one never hears about the "other commodity price volatility curse".

3.2.1.3. Crowding-out of human capital

While there has been a consensus that human capital plays a vital role in driving economic growth, some researchers have shown that resource-abundant countries and regions tend to lack human capital. Consequently, they consider the crowding-out effect of natural resource dependence on human capital as a crucial transmission mechanism of the resource curse (Gylfason, 2001; Shao, 2014; Talvi et al., 2018). Gylfason (2001, pp.851-855) shows that “public expenditure on education relative to national income, expected years of schooling for girls, and gross secondary enrolment are all inversely related to the share of natural capital in national wealth across countries”. For him, the wealth of natural resources might be ‘blinding’ resource-rich countries from investing in education and building higher-quality human capital for their societies. Other scholars see low investment in human capital in these countries because of deliberate policy choices. For example, Ross (2001) opined that politicians in natural resources-rich countries have less motivation to provide a higher quality of education because they believe that government revenues are mostly obtained from exports of natural resources rather than from internal tax revenues. Similarly, Acemoglu and Robinson (2006) argue that governments in these countries might intentionally discourage investment in human capital and institutions to remain longer in power.

Following Gylfason (2001), several other scholars have argued that natural resources hamper human capital development, emphasising lower returns from human capital investment relative to the resource sector. As summarised by Shao (2014), their basic viewpoint is that “human capital investment gains no expected income as compensation and thus households' desire to receive education declines in the resource-based economy, causing the deficiency in the driving force of human capital accumulation" (p. 633). For example, Birdsall, Pinckney, & Sabot (2001) look at the story as told by the data and find that resource-abundant countries, on average, invest less in education than other countries. Using a conceptual framework of a "virtuous growth circle based on human capital accumulation," their paper argues, "[A] resource boom can reduce the expected return of human capital investment and break the virtuous circle." Talvi et al. (2018) suggest two ways in which investment in human capital could be neglected in resource-rich countries. First, due to the lower economic returns of human capital investments relative to the natural resources sector, there is no pressure on the government to implement appropriate policies to develop human capital programmes. Second, improvements in human capital through learning-by-doing might not be effective if international firms dominate the natural resource sector. This is mainly because these firms prefer bringing their own skilled labour rather than training on-the-job local workers.

Notwithstanding the strength of the argument in favour of the resource curse through the human capital development channel, Shao (2014) makes mention of a strand of research arguing that "the crowding-out effect of a resource boom on human capital is not inevitable and that those countries, which have successfully evaded the resource curse, tend to have a higher level of human capital" (p.633). In the same vein, Davis (1995) reports supporting evidence that human capital accumulation indicators are higher in mineral countries than non-mineral countries. This finding is supported by Stijns (2001), who reports that human capital indicators are shown to be positively associated with resource abundance and mineral rent indicators. Stijns vindicate his findings on the ground that that he used a richer human capital dataset as well as plausible proxies for resource abundance, looking at subsoil wealth per capita instead of the ratio of natural capital in overall wealth. Moreover, he controls for other determinants of human capital besides resource abundance." Like Stijns and Davis, Weber (2014) also reports findings indicating that increased natural gas production in the natural resource-rich South-Central US did not lead to a less educated population in the 2000s.

A recent survey study by Alssadek and Benhin (2023) identified numerous other studies in the literature that assessed the impact of natural resources on human capital development. A sheer number of them have used education as an indicator of human capital, while few recent ones have employed health indicators. Overall, no consensus has been reached as to whether natural resources adversely affect growth via their effect on human capital.

3.2.1.4. Financial development and resource curse

The crowing-out effect of natural resources is not limited to human capital. A growing body of research has argued that resource abundance slows down the pace of financial development systems. Starting with Gylfason & Zoega (2001), their paper shows empirically that abundant natural resources crowd out physical capital in terms of lower optimal savings and investments, as well as slowing down the emergence of a well-developed financial system. Atkinson and Hamilton (2003) report findings indicative of lower savings rates on average in resource-abundant countries than in resource-poor countries. Papyrakis and Gerlagh (2006) show that, given that capital accumulation becomes less important for sustaining future income levels in resource-rich economies, mineral resource abundance is associated with reduced savings and investment rates.

Several causal chains have been identified, including the adverse effect of natural resources on demand for savings, increased corruption and rent-seeking activities, poor contract enforcement and social trust, inefficient allocation of resources, and macroeconomic volatility. Alssadek and Benhin (2023) provide a list of key research papers and a review of the growing literature on financial development. Most of the empirical papers reviewed support finding of resource curse via financial development. Beck's (2011) paper focuses on financial deepening in resource-based economies by exploring the role and structure of the financial system. It documents the existence of less developed financial systems in resource-rich economies and banks that are more liquid, better capitalised, and more profitable but give fewer loans to firms. Beck noted that, although the level of demand is the same in resource-rich countries as in other countries, firms in resource-abundant economies use less external finance, and a smaller share of them use bank loans, pointing to supply constraints and suggesting a resource curse in financial development.

Scholars have also argued that, where the quality of institutions is low, revenues from natural resources increase corruption and rent-seeking activities, which adversely affect key determinants of financial development, such as entrepreneurship, private investment, contract enforcement, and social capital or level of trust (see e.g., Mo, 2001; Ndikumana and

Baliamoune-Lutz, 2008; Bhattacharyya and Hodler, 2014; Bologna and Ross, 2015, Guiso et al., 2004; Yuxiang and Chen, 2011, as cited by Alssadek & Benhin, 2023). Yuxiang and Chen (201), David et al. (2014); Menyah et al. (2014) (as cited by Alssadek & Benhin, 2023) focus on the production effect of the Dutch Disease and argue that it lowers productivity growth of the tradable manufacturing sector, which reduces firms' need for financial resources from the financial system. Moreover, the inefficient allocation of resources from Dutch disease reduces the tradable sector and can also constrain financial development.

Another strand of literature has explored resource curses, focusing on the role of institutions. For example, in their endowment theory of financial development, Beck, Demirguc-Kunt, and Levine (2003) posit that resource endowment, and the disease environment encountered by the colonizers influenced the quality and nature of the colonial institutions they erected. They show that in countries with unfavorable disease environments, the colonizers decided not to settle and erected extractive institutions. These extractive institutions, characterized by weak property rights and contract enforcement, persisted over time and continue to negatively influence financial and economic development. Using a cross-section sample of 70 former colonies, their analysis finds that the endowment theory explains most of the cross-country variation in financial development. Similarly, Acemoglu and Johnson (2005) show that endowment impacts financial development through property rights institutions (which protect citizens from expropriation by those in power) and not through contracting institutions (which regulate transactions among private citizens). These authors present a politico-economic model in which contract enforcement is low and decreasing in resource revenues when political institutions are poor, but high otherwise. As poor contract enforcement leads to low financial development, the model predicts that resource revenues hinder financial development in countries with poor political institutions but not in countries with comparatively better political institutions. Using panel data covering the period 1970–2005 and 133 countries, they test the theoretical predictions of their model and provide estimates that confirm their theoretical predictions.

3.2.2. Political Economy and Institutional Approaches

Dissatisfaction with the mainstream economic explanations of the resource curse has attracted political scientists and institutionalists to natural resource curse research. These researchers have developed an alternative perspective dubbed “the institutional approach.” Two sub-streams of research within the institutional approach can be clearly identified (Alssadek & Benhin 2023; Badeeb et al. 2017; Gilberthorpe & Papyrakis, 2015). The First “treats institutions as an endogenous variable that is dependent on the abundance of mineral rents and sees natural resource abundance as a cause of institutional degradation and corruption” (institutions as dependent variable) (Gilberthorpe & Papyrakis, 2015, p.4). The second “does not explain any variability in institutions as a result of mineral abundance; rather it emphasises the mediating role of good institutions in preventing the resource curse” (p.4). Scholars in this strand stresses that it is the quality of institutions that principally determines whether natural resource abundance is a blessing or a curse (Institutions as a mediating variable) (Boschini et al., 2007; Mehlum et al., 2006; Sarmidi et al., 2014).

3.2.2.1. Institutional degradation, corruption, and rent- seeking.

Scholars who treat institutions as endogenous variable emphasize the institutional channel for the curse and point to the role of rent seeking[14] and corruption, distorted incentives for democratic governance, civil wars, and violent conflicts in weakening the quality of institutions. Their arguments are in line with different forms of the rentier state theories outlined in Ross (1999) and which underscores different causal links between resource rents and poor economic governance.

Among the studies in this first strand of literature, Leite and Weidmann (1999), Tornell and Lane (1999) and Isham et al. (2005) showed that natural resources hamper the development of a good institutional framework by incubating non-economic activities such as corruption and rent-seeking, especially for point resources (oil, gas, mineral) that are under the control of the government. They argue that rents from point natural resources are easily extracted by the ruling and powerful elite groups to accumulate their wealth; these groups “generally take a large share of these revenues and distribute it for the benefit of their immediate circles rather than investing it to upgrade infrastructure and sustainable economic development” (Badeeb et al., 2017, p.126). "That situation develops into a vicious cycle of rent-seeking, which pervades

[14]Kaznatcheev (2017, p.12) draws a distinction between illegal and legal rent-seeking activities. Rent seeking, he explains, “is not just corruption through bribery, although bribery is very often part of rent-seeking”. “Corruption and bribery are in the first category of illegal activities, whereas the second category includes a broad range of activities, such as creating regulatory barriers to entry, ring-fencing mineral licenses for a certain group, or channelling state subsidies”.

the society from top to bottom and does so in a very unequal measure" (Kaznatcheev, 2017, p.18). In their model of "Grabber friendly vs Producer friendly" institutions, Mehlum, Moene, and Torvik (2006, p.3) show that "with grabber friendly institutions, there are gains from specialisation in unproductive influence activities, for instance due to a weak rule of law, malfunctioning bureaucracy, and corruption". In countries with such institutions, a windfall of resource revenues creates incentives for engaging into unproductive activities, crowding out scarce entrepreneurial resources out of production, with particularly adverse effect on growth. Ross (2001), Isham et al. (2005) and Sala-i-Martin and Subramanian (2013) argued that natural resources thwarted institutional improvement by delaying transition to democratic governance, restricting political rights and civil liberties, and diminishing the rule of law, therefore leading to poor economic growth. Similarly, Beck (2011, p.6) stresses that "natural resource wealth allows less than democratic governments to buy off opposition, avoid accountability, and prevent transparency. Natural resources make it more profitable for the elites to hang on to power and block the development of an open society" (citing Beck & Laeven, 2006).

Badeeb et al. (2017, p.126) point out that "windfall resource revenues are also considered a main cause for conflict between domestic stakeholders such as politicians, local tribes, and citizens more broadly" (citing Bodea et al., 2016; Davis and Tilton, 2005; Iimi, 2007; Sala-i-Martin and Subramanian, 2003). Alssadek & Benhin (2023) also underline the greed of looting rebels and dissatisfaction about the unequal distribution of revenues from natural resources put countries at risk for the potential onset of civil war, which deteriorates the quality of institutions" (citing Collier & Hoeffler, 2005; Rosser, 2006; De Soysa & Neumayer, 2007). Collier & Hoeffler (2004) report evidence indicating that for any given five-year period, the chance of a civil war in an African country range from less than 1% in countries without resource wealth to nearly 25% in those countries with it.

3.2.2.2.Mediating role of institutions

The second sub-stream of the institutional approach does not treat institutions as an endogenous variable that is dependent on the abundance of mineral rents; it emphasises the mediating role of good institutions in preventing the resource curse" (Mehlum et al., 2006; Sarmidi et al., 2014). It argues that it is the (exogenous) quality of institutions that determines whether resource rents pose a resource curse or blessing. Its core message is that "sound institutions (e.g. secure property rights, efficient bureaucracies, low corruption) can turn the 'resource curse' into a 'resource blessing'" (Gilberthorpe & Papyrakis, 2015, p.4). Mehlum et al. (2006a, p.3) argue that "Institutions are decisive for determining whether resource revenues bring curse or blessing". They point out that natural resources decrease economic growth only in countries with grabber-friendly institutions (bad), while they increase economic growth only in countries with producer-friendly institutions (good). They show what accounts for difference in growth performance among resource-rich countries, such as Norway and Botswana on the one hand and Nigeria and DR Congo on the other, must do primarily with how their resource rents are distributed through institutional arrangements. Unlike the latter two countries, the institutions of Norway and Botswana are characterised by inactive rent-seeking behaviour, higher quality bureaucracy, lower levels of corruption, secure property rights, higher levels of transparency and accountability, as well as a small risk of government repudiation of contracts.

Scholars have also provided several cases of sluggish growth among resource-rich countries characterised by weak institutions. Lane &Tornell (1996) and Tornell & Lane (1999) explain the disappointing economic performance after the oil windfalls in Nigeria, Venezuela, and Mexico by "dysfunctional institutions that invite grabbing". Acemoglu et al. (2006, p.171) argue that "higher resource rents make it easier for dictators to buy off political challengers". They show that in the DR Congo, the enormous natural resources gave Mobutu (*and subsequently Joseph Kabila*) a constant flow of income to help sustain his power. "Such perverse political incentives of resource abundance are only mitigated in countries with adequate institutions" (Mehlum et al., 2006, p.4).

Several other research papers show that good institutions play a preventive role against rent-seeking activities. For example, Tornell and Lane (1999) show that interaction between weak institutions and a mineral boom can result in numerous interest groups competing for the rents, a phenomenon dubbed the "voracity effect". On their part, Boschini et al. (2007) introduce the notion of "appropriability" of mineral rents and link the incentive to rent-seek to institutional quality as measured by the extent of property rights protection. In the same vein, Torvik (2009) argues that a good institutional apparatus averts the negative effects of natural resource endowments on growth. Similarly, Sarmidi et al. (2014) shows that the negative effect of natural resource abundance on growth can vanish as institutional quality improves.

Critics of political scientists and institutional economists have argued that "although these scholars have produced score of explanations, they have rarely tried to test their theories with either well-selected comparative cases or large-N data sets" (Ross, 1999, p.299). Despite this critique, Mehlum et al. (2006) opined that the institutional approach's message is consistent with observations from several countries, pointing to the most cited examples of Botswana and Norway. They point out that Botswana, with 40% of GDP stemming from diamonds, has had the world's highest growth rate since 1965. Norway – which was one of Europe's poorest countries in 1900, is now one of its richest. "Its growth was led by natural resources such as timber, fish, hydroelectric power, and later oil and natural gas" (p.4). Acemoglu, Johnson, & Robinson (2002) attribute the remarkable performance of Botswana to its good institutions.

3.3. EMPIRICS OF THE RESOURCE CURSE

Empirical work on the natural resource curse started with case studies, notably by Gelb (1988) and Auty (1990, 1993). Sachs & Warner's seminal paper (1995) is one of the first significant systematic studies to confirm the adverse effects of natural resource abundance on growth based on a worldwide, comparative study of growth. Using the empirical framework introduced in Barro (1991) and extended in Barro & Sali-Martin (1995), this paper examines ninety-seven countries over a nineteen-year period, using regression analysis to measure the impact of mineral and other resource exports on GDP growth. This study reports findings showing that "countries with a high ratio of natural resource exports to GDP in 1971(the base year) tended to have low growth rates during the subsequent period 1971-89". They show that this negative relationship holds true even after controlling for variables found to be important for economic growth, such as initial per capita income, trade policy, government efficiency, investment rates, and other variables. In a subsequent paper, Sachs, and Warner (2001, p.828) stress that "this negative relationship is not easily explained by other variables, or by alternative ways to measure resource abundance". Furthermore, "there is little direct evidence that omitted geographical, or climate variables explain the curse, or that there is a bias resulting from some other unobserved growth deterrent." Sachs and Vial (2001) also report finding that an alternate measure of resource abundance – share of natural resource exports in total exports – affects growth negatively.

Following Sachs and Warner's ground-breaking findings, the empirical literature has flourished over the last three decades. The evidence, however, has been heterogeneous, with little consensus in the empirical literature on the effect of natural resource abundance/dependence on economic growth or on factors associated with it. Badeeb et al.

(2017) assess that “the empirical evidence regarding the resource curse overall or its specific causal channels is rather mixed and can be categorized into three groups” (p.127). The first group follows Sachs & Warner's empirical specification and supports their findings, albeit using various measures to capture resource abundance or resource dependence. These empirical studies evaluate the direct impact of natural resources on growth. Existing surveys provide a summary of these studies (Alssadek & Benhin, 2023, table 1; Badeeb et al., 2017, tables 2-3). The second group tends to shed doubt on the validity of the resource curse hypothesis (e.g., Brunnschweiler & Bulte, 2008; Cavalcanti, Mohaddes, & Raissi, 2011; James, 2015; Lederman & Maloney, 2007; Stijns, 2005). The third group focuses on testing the resource curse through various economic factors that are believed to drive long-term growth, such as human capital development, entrepreneurship, financial development, growth of manufacturing exports, real exchange rates, institutional quality, etc. (see Alssadek & Benhin, 2023, tables 2-6; Badeeb et al. 2017, table 2).

One of the early empirical works to cast doubt on the resource curse is the paper by Manzano and Rigobón (2001) who assess the relationship between natural resource abundance and economic growth, or the growth rate of GPD per capita. They identify two important econometric problems present in Sachs and Warner’s (1995) influential paper. First, they point out that the finding of the resource curse might depend on factors that are correlated with primary exports but that have been excluded from the regression. Second, total GDP includes production in the resource sector, which has been declining in the last 30 years. Correcting for these issues by moving from cross-section regression to panel context and using standard fixed effects for unobserved country characteristics, they find that the resource curse disappears. Seeking to explain Sachs and Warner’s findings, they present results indicating that the so called “Natural Resource Curse” might be related to a debt overhang; that is, as commodity prices declined from the late 1970’s, natural resource-rich economies suffered from a debt overhang that stifled growth beyond the slowdown expected due to declining prices. When they estimated the model, taking this into account, they found that the effect of resource abundance again disappeared.

Bravo-Ortega and de Gregorio (2005) conduct an empirical assessment of the resource curse using a model in which natural resources have a positive effect on the level of income and a negative effect on its growth rate. They evaluate their model using panel data for the period 1970-1990. They extend the usual specifications for economic growth regressions by incorporating an interaction term between human capital and natural resources, hypothesising that elevated levels of human capital may outweigh the negative effects of natural resource abundance on growth. They find that, while it is theoretically plausible that natural resources could reduce the rate of economic growth by a "Dutch disease" effect, this partly results from the fact that resources produce a higher level of development in the long run (or in the steady state of an economy), even if they reduce the rate of income per capita in the short run. Further, using Sachs and Warner's resources over GDP proxy as well as resource exports over total exports, they empirically confirm that the effects of natural resources on the pace of growth crucially depend on the availability of human capital. Their results show that the marginal effect of the stock of natural resources on income growth rises and becomes positive as the stock of human capital rises.

In the book titled "Natural Resources: Neither Curse nor Destiny" edited by Lederman and Maloney (2006), two economists at the World Bank, the authors examine the econometric evidence on whether natural resources are curses and raise doubts over the very attempt to generalise about the effect of natural resources on growth and development. Using panel data specification to better control for unobserved fixed effects, dynamics, and endogeneity, their analysis reports findings that, regardless of the econometric technique applied, several plausible indicators of the incidence of natural resource exports seem to have positive rather than negative effects. These authors point out that the critical difference with many previous works arises from the fact that, in constructing their cross-country database, Sachs and Warner replace their principal measure of abundance – natural resource exports as a share of GDP – with net exports as a share of GDP for two countries, Singapore and Trinidad and Tobago, suggesting that some of the indicators used in previous analyses might be unrelated to relative natural resource endowments. In view of their results and the existing econometric evidence provided by Bravo-Ortega et al. (2005) and Manzano et al. (2001), they bluntly conclude that "the curse of natural resources does not exist", adding that "economists have been trying to generalize about the effect of resource abundance while failing to discover precisely which characteristic is affecting growth negatively" (Lederman & Maloney, 2006, p.32).

Brunnschweiler & Bulte (2008) critically evaluate the empirical basis for the curse of natural resources. They explore the underlying factors that determine resource dependence and institutional quality and properly account for them in 2SLS and 3SLS regression analyses of economic growth. Further, they explore the impact of an alternative and exogenous measure of resource abundance (based on the value of resource stock) on economic growth and institutional quality. In multiple estimations that combine resource abundance and dependence, institutional, and constitutional variables, they find that (i) resource abundance, constitutions, and institutions determine resource dependence, (ii) resource dependence does not affect growth, and (iii) resource abundance positively affects growth and institutional quality. They conclude that there exists a discrepancy between the theory behind the curse and the empirical work used to support it.

Cavalcanti, Mohaddes, and Raissi (2011) study the impact of the level and volatility of commodity terms of trade (CTOT) on economic growth, as well as on the three main growth channels: total factor productivity, physical capital accumulation, and human capital acquisition. To account for cross-country heterogeneity and cross-sectional dependence, they use the standard system GMM approach as well as an augmented version of the pooled mean group (PMG) methodology of Pesaran et al. (1999) for estimation. Using both annual data for 1970-2007 and five-year non-overlapping observations, they find that while commodity terms of trade growth enhance real output per capita, volatility exerts a negative impact on economic growth, operating through a lower accumulation of physical capital. Their results indicate that the negative growth effects of CTOT volatility offset the positive impact of commodity booms. They argue that volatility, rather than natural resource abundance per se, drives the resource curse.

The empirical studies have also investigated the resource curse by focusing on transmission mechanisms through factors associated with long-term economic growth. Starting with Gylfason (2001), his paper tests the effect of natural resources on human capital accumulation. His analysis reports findings showing that public expenditure on education relative to national income, expected years of schooling for girls, and gross secondary-school enrolment are all inversely related to the share of natural capital in national wealth across countries. This paper concluded that natural capital appears to crowd out human capital, thereby slowing down the pace of economic development. This finding is supported by Birdsall, Pinckney, and Sabot (2001) who argue that, in spite of the expectation that resource abundance should release binding government constraints and induce additional investment in human capital, data suggest that, on average, countries rich in natural resource invest less in education than resource-poor countries, There is also empirical evidence showing that an increase in natural resource endowment reduces engagement in productive entrepreneurship. Majbouri (2016) analysed this relationship, testing whether rents produced from natural resources, especially oil and gas, may reduce engagement in entrepreneurial activities as they may change incentives towards rent-seeking. Using Global Entrepreneurship Monitor (GEM) annual surveys, his study provides empirical evidence showing that more per capita profit from oil and gas reduces entrepreneurship only in corrupt environments. The more the corruption is, the larger is the impact. This is in line with the results reported by Chen, Wang, and Cheng (2012) who find, in the context of provincial economic growth in China, that the increase in natural resource endowments directly improves the expected returns of entrepreneurial rent-seeking, thereby leading to the shift of entrepreneurial talent from productive sectors with low returns to rent-seeking sectors with high returns. He concluded that this distortion reduces regional economic growth, resulting in a resource curse.

In the context of Africa, several empirical research papers report findings of resource cruse. The survey study by Alssadek and Benhin (2023) identified ten research papers published between 2014-2022, focusing on sub-Saharan countries. Nine of these papers report a finding of resource curse. We present in **Appendix F (Empirics of Resource Curse in Sub-Saharan Africa**) a summary of these studies, including the sample period, the country groupings, the natural resources measurements, the estimation methods, and the key results. It appears from this research that resource wealth affects growth and development outcomes mostly through its effects on human capital development, governance structure, quality of government institutions and the incidence of violent conflicts. Overall, the findings from these studies tend to be consistent with the evidence cited in Ross (2015), which shows that natural resources (in particular petroleum wealth) seem to have at least three harmful effects: "to make authoritarian regimes more durable, to increase certain types of corruption, and to foster the onset of violent conflict in low- and middle income countries, particularly when this form of mineral wealth is found in the territory of marginalized ethnic groups" (Abstract).

As this review reveals, the empirical evidence regarding the resource curse overall or its specific causal channels is mixed, with a great deal of heterogeneity in the results. As rightly recognised by Badeeb et al. (2017) in the conclusion of their survey of literature on resource curse, a sheer number of empirical studies confirm an adverse effect of natural resources on growth or on its determinants. Yet a few studies have successfully attempted to prove the contrary, particularly where resource abundance rather than dependence is the explanatory variable of interest. Badeeb and co-authors attribute these later studies' contradictory results to different type of resources being examined, different economic backgrounds, and the choice of measure of key variables such as natural resource importance, economic growth, or years over which studies have been conducted. This point is consistent with Ross (2015) who find that the nature of natural resource matters for the finding of harmful effects of natural wealth, whether it is through government accountability, quality of institutions or violent civil wars. In all these cases, petroleum seems to matter the most for the finding of evidence in favour of the resource curse, which leads Ross to take a position that the resource curse is essentially ' oil curse'.

The overwhelming evidence that the presence of natural wealth abundance, oil in particular, is the most associated with adverse effects on growth and development has sparked radical critiques of the resource curse theory by scholars who contend that the issue is '***rent theft'***, not ' rent seeking' (e.g., Obeng- Odoom, 2020, 2017; Obi, 2023, 2010). These works contend that the resource curse doctrine does not only fail to provide explanation for the crisis of development in resource-rich African countries but also serves to obfuscate the problem of global capitalist extraction system. Obi (2010) argues that explaining such conflicts based on the ways natural resources either function as an incentive for rebel groups, or erode or weaken states, does not adequately capture the complex histories, dimensions, and transnational linkages to civil conflicts in Africa. He locates oil in global capitalist extraction and argues that the misgovernance of oil resources in Africa is rooted in, and renewed by the structures of inequality, extraction, and dependence, which underpin continent's integration into the global capitalist system (Obi, 2023).

Recent meta-analysis regressions shed some light and helped identify sources of heterogeneity in the results from the empirical studies reviewed in the previous section. For example, in a quantitative survey of 605 estimates reported in 43 studies, Havranek et al.(2016) find that, overall, there is weak support for the resource curse hypothesis, especially when potential publication bias and method heterogeneity are taken into account. Their findings show 40% of 43 studies analysed report a negative and statistically significant effect of natural resources on economic growth; another 40% report no effect, and the remaining 20% report a positive and statistically significant effect. Their results point to four aspects of study design that might explain the differences in results across studies: (i) controlling for institutional quality; (ii) controlling for the level of investment activity; (iii) distinguishing between distinct types of natural resources, and (iv) between resources dependence and abundance." Similarly, Dauvin and Guerreiro (2016) implement a meta-analysis based on 67 empirical studies that investigate the link between natural resources and growth, totalling 1405 estimates. The results show a "soft" curse that may be reverted, together with the importance of institutions in mitigating the curse. Further, this study identifies three sources of heterogeneity in the literature: (i) the use of abundance and intensity measures; (ii) the account for appropriability aspects of resources; and (iii) the role of institutions.

3.4. RESEARCH GAPS AND WAY FORWARD

Despite the heterogeneity in their results, empirical studies on the curse of natural resources have in common that they primarily rely on the empirical growth framework introduced by Barro (1991) and extended in Mankiw et al. (1992). This framework is underpinned by the one-sector neoclassical aggregated growth model and its subsequent variants that endogenize technological change. Not surprisingly, all empirical growth models specified in resource curse literature completely ignore or neglect the role of a country's productive structure and structural transformation in driving economic growth and productivity improvements.

However, several studies have argued that one-sector models are inadequate for studying economic growth in developing countries, which are still typically characterised by substantial sector heterogeneity and large gaps in sectoral productivity (Diao et al., 2019; Herrendorf et al., 2014,Temple, Ranis, 2006; , Restuccia, 2011; Temple, 2005). Further, there is a growing body of empirical literature combining the power of big data and machine-learning techniques, showing that the productive structure of a country's economy is a harbinger of growth and a key determinant of cross-country differences in growth and income levels (Cristelli et al., 2017; Hidalgo & Hausmann, 2009). Economic complexity scholars have argued that complex capabilities embodied in the productive structure of an economy are what explains "why China has succeeded and why it will continue to do so" (Felipe, Kumar, Usui, & Abdon, 2013). Combined, these arguments suggest that previous empirical works on resource curse are grounded on a theoretical framework that only partially captures the main feats of developing countries 'economies.

There are both conceptual and econometric issues that cast doubt on the validity of the existing empirical body of evidence on resource curses. First, conceptually, economic growth scholars have widely recognised that accounting for cross-country differences in aggregate growth with aggregate models has been challenging for various reasons (see Bruns & Ioannidis, 2020; Ciccone & Jarocinski, 2010; Durlauf, Johnson, & Temple, 2005; Easterly & Levine, 2001; Hausmann et al., 2011; Rockey & Temple, 2016). The aggregate modelling approach does not account for dual structure of developing economies (Temple, 2005) nor the complexity and interconnectedness of the economic system (Hidalgo & Haussmann, 2011; Cristelli et al.2015); as such, it neglects the possible effects of uncountable heterogeneous interactions occurring at different scales of the economic system (Cristelli et al., 2017). Furthermore, these scholars point out that the regression-based approach is particularly appropriate only under the assumption that the economic system responds homogenously to a specific set of independent variables. This is rarely the case in economic systems, which are heterogeneous (Cristelli et al, 2015).

Resource curse researchers have tried to account for the complex and heterogeneous interactions among actors and factors at various levels of growth and development processes by specifying and estimating growth models with many interactive variables and parameters. While intuitively appealing, this type of modelling offers the illusion of being able to capture all the components that drive economic growth (Tacchella et al., 2018, p.) and is affected by the curse of dimensionality – i.e., "as you measure economic performance in more ways, it becomes difficult to state anything definitive about the similarity of different economies without unrealistically long histories of countries' evolution (Cristelli et al., 2017, p.). In some cases, resource curse researchers have undertaken efforts in the sense of oversimplified representation that aim at understanding the potential effect of natural resource dependence and abundance variables on a limited set of variables in an interactive and controlling setting. However, in doing so, their modelling neglects the possible effects of complex interactions among many factors in the economic system and is susceptible to omission variable bias.

Second, there are econometrics-related issues, due to the structure of the data used, model specifications, and estimation methods employed. With respect to the data used, whether in cross-section or panel data, all empirical studies on the curse of natural resource use annual observations in estimating the long-term relationship between growth and its determinants. For those using dynamic panel data models especially, this is dictated by the need to have enough time-series observations (T) to justify the use of estimation methods developed for cointegrating vectors in panel data setting. However, seminal contributions on growth regression emphasize that yearly time spans are short and inappropriate to studying growth convergence (Barro, 2003; 2012; Beck, 2000; Caselli et al. 1996). To avoid modelling cyclical business dynamics, these economic growth scholars recommend using spans of at least five-year time intervals.

Regarding modelling and estimation methods, early studies investigating the natural resource curse used the standard empirical growth regression in a cross-section setting and relied on estimation methods that have been shown to produce inconsistent estimates. As argued and demonstrated by Caselli et al. (1996, p.364), this inconsistency stems from two sources. First, "the incorrect treatment of country-specific effects representing differences in technology or tastes, gives rise to omitted variable bias." Second, failure to properly control the endogeneity of at least a subset of explanatory variables, which is driving standard results in growth empirics. While the resource curse hypothesis tends to be rejected in subsequent works conducted in panel data settings, it is observed that static panel data models are often specified without accounting for the dynamic nature of the growth process. Moreover, the standard fixed and random effect estimation methods employed do not control the problem of endogenous explanatory variables included in growth regression. Where dynamic panel data models are specified, estimation methods designed for cointegrating vectors in heterogeneous panel settings are blindly employed without due regard to the time dimension of the panel (T) and the potential business cycle fluctuations or other various shocks in the annually observed data. These methods include Pooled Mean Group (PMG), Feasible Modified OLS (FMOLS) and Dynamic OLS (DOLS) - which require hard-to-satisfy assumptions regarding the time dimension of the panel and the properties of the regressors in order to guarantee consistency of the estimates and validity of the statistical inference (Pesaran et al. 1999; Pedroni, 2001). For example, Pedroni (2001) shows that the FMOLS estimator raises serious concerns with respect to the small sample properties of the associated t-statistic and the possibility of large-size distortions. He shows that this often results in false inference, "since in this case, the tests are likely to report rejections of the null hypothesis when in fact it is not warranted" (p.).

While virtually all survey studies unanimously agree that there is currently no consensus regarding the existence of a natural resource curse, one such study concludes that "the theoretical mechanisms proposed by which resource dependence can hamper growth directly or via key determinants of growth seem to us to remain plausibly valid until proven otherwise" (Badeed et al., p. 132). Nonetheless, all these surveys suggest that further work needs to be conducted in different country groups using different time periods, different growth determinants, and different modelling approaches to be able to conclusively rule out the resource curse. This study, therefore, will re-examine the role of natural resources in a way that has not been previously attempted. First, we build an empiric bridge between the neoclassical growth theory and the structural transformation literature by including a new determinant in the standard growth regression model. Most specifically, we model in the growth process the capabilities embedded in the productive structure of a country's economy, measured by the economic complexity metrics. Further, we use these metrics to not only unveil the growth potential and dynamics of individual sub-Saharan resource-rich and resource-poor countries, but also to examine and compare their patterns of structural transformation and profile of their industrial specialisation and competitiveness in different sectors. Therefore, the next chapter lays the conceptual groundwork for the economic complexity approach to growth and development.

CHAPTER 4

ECONOMIC COMPLEXITY AND PRODUCT SPACE FRAMEWORK

4.1. INTRODUCTION

With hyper specialisation in specific tasks becoming the driving force behind efficiency gains from a much finer international division of labour in global value chains production (World Bank, 2020), the concept of specialisation and division of labour developed by Adam Smith (1776) is more than alive. For the founding father of economics, the efficiency of the production was vastly increased because workers were split up and given separate roles in the making of a pin. As people and firms specialize in different activities, their productive power, skill, and dexterity improve, increasing the overall economic efficiency. The division of labour, however, was limited by the extent of the market - the bigger the market, the more its participants can specialize and the deeper the division of labour that can be achieved. For Hidalgo and Hausmann (2009), the key message from Smith's inquiry suggests that "wealth and development are related to the complexity that emerges from the interactions between the increasing number of individual activities that conform an economy" (p. 10570).

Drawing on the prediction of Smith's model about specialisation and division of labour, Hidalgo and Hausmann move on to address a long-standing question that has puzzled economists: "if all countries are connected to each other through a global market for inputs and outputs so that they can exploit a division of labour at the global scale, why have differences in GDP per capita exploded over the past two centuries?" (p.10570). In full, the answer from these scholars is as follows:

One answer is that some of the individual activities that arise from the division of labor described above cannot be imported, such as property rights, regulation, infrastructure, specific labour skills, etc., and so countries need to have them locally available to produce. Hence, the productivity of a country resides in the diversity of its available non-tradable "capabilities," and therefore, cross-country differences in income can be explained by differences in economic complexity, as measured by the diversity of capabilities present in a country and their interactions. (p. 10570).

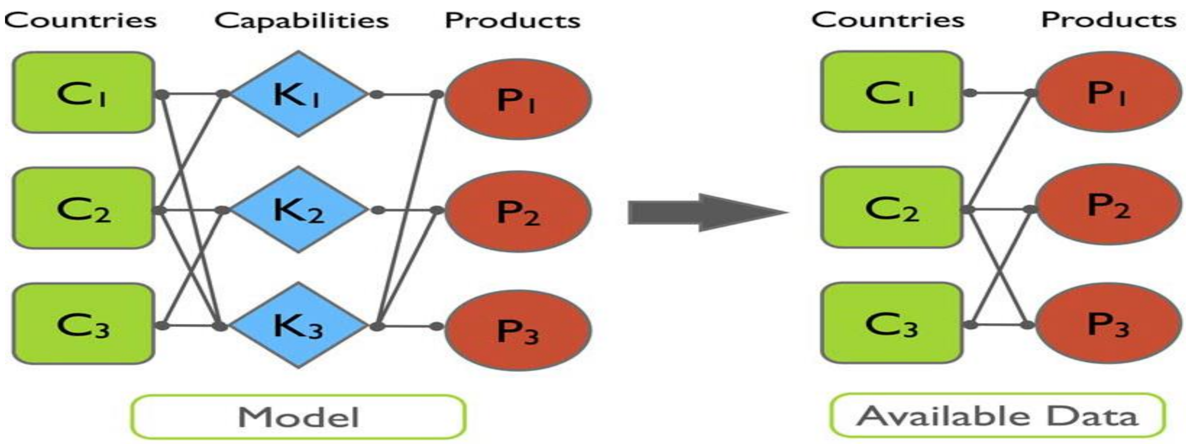
Hidalgo and Hausmann rightly note that the role of input diversity or complexity has been intuitively implied in endogenous economic growth models (citing Grossman & Helpman, 19991; Aghion & Howitt, 1998). These models included the assumption that "the variety of inputs that go into the production of the goods produced by a country affects that country's overall productivity;" however, they observe, "there have been very few attempts to bring this intuition to the data" (p. 10570).

To better illustrate their concept of complexity, Hidalgo and Hausmann use an analogy to a building block or Lego piece. They compare a product to a Lego model and a country to a bucket of Legos, showing that, just like a child is able to produce a Lego model if his/her bucket contains all of the necessary Lego pieces, countries will be able to make products (goods and services) for which they have all of the required capabilities. In another analogy of a game of scrabble used in Hausmann, Hidalgo et al. (2014), each product is equivalent to a word, and each capability, or module of embedded knowledge, is equivalent to a letter. Players with a more diversified set of letters will be able to make more and longer words. Similarly, countries with more capabilities will make more complex products. In other words, the diversity of words (products) that a player (country) can make will be strongly dependent on the number of letters (capabilities) that he/she has. Long words (complex or sophisticated products that require large variety of capabilities) will tend to be rare since they can only be composed by players (countries) with many letters (capabilities), whereas shorter words (fewer complex products) will be more common or ubiquitous.

Building on the intuition behind these analogies, Hidalgo and Haussmann (2009) develop metrics to quantify the productive knowledge and capabilities embedded in the country's economic system, emphasizing that the essence of economic complexity is to infer the diversity and exclusivity of capabilities present in a country by looking at the products which it makes, just as one can infer the diversity and exclusivity of the Lego pieces (letters) inside a child's (player's) bucket by looking only at the models (words) that a group of children (players), each with a different bucket of Legos (letters), can make. They show that it is possible to derive these metrics if one interprets data connecting countries to the products they export as a bipartite network and assumes that this network is the result of a larger, tripartite network connecting countries to the capabilities they have and products to the capabilities they require. Furthermore, they show that these measures of complexity are correlated with a country's level of GDP per capita and that deviations from this relationship are predictive of future economic growth.

More formally, Cristelli et al. (2013) show that it is possible to represent schematically the economic complexity framework in terms of a tripartite country-capability-product network in which capabilities are the intermediate layer between countries and products. As rephrased in Cristelli, Tacchella, Cader et al (2017), this is achieved by stating that the economic output can be seen as the result of country specific tripartite networks where the three composing layers are the economic actors (here countries), the capabilities and the economic activities (or products). A tripartite network is in general defined as a network in which nodes can be grouped into three classes C, K and P such that links are permitted only between nodes belonging to two different classes. In the present case, a node in the classes C (countries) and P (products) can only be connected to nodes in the class K (capabilities).

Figure 4.1. A schematic representation of the hidden capabilities layer



Notes: On the left, capabilities (blue diamonds) are conceptually visualized as an intermediate level in a tripartite country-capability-product network. On the right, a bipartite network-defined by countries (green squares) and economic output/products (red circles) – can be interpreted as the projection of the tripartite network. In this bipartite country-product network, each country is connected to all and only those products for which it owns all the necessary capabilities they require to be produced. Being the result of heterogeneous economic dimensions and hardly measurable interactions, the tripartite modelling is intractable via a direct approach. Nevertheless, bilateral trade data are a robust proxy for the bipartite country-product network from which information on capabilities can be inferred. [Source: Cristelli et al. (2013. 2017); Sbardella et al. (2021).]

Cristelli and co-authors note that, due to the non-observability of capabilities, one can only access the ‘‘contraction’’ of this tripartite network into the bipartite country-product network. In this bipartite network, exports of countries can be informative about the presence of specific capabilities, just like the creation of a model (word) by a child (player) signals the availability of a specific set of Lego pieces (letters). The intuition behind the tripartite network is elegantly spell out in Hidalgo and Hausmann (2011).

Countries with more capabilities have what it takes to make more products and will be more diverse, whereas countries with less capabilities will find it hard to make more products, especially those that require more capabilities. The latter will be accessible to fewer countries, i.e., they will be less ubiquitous. Hence, more complex countries will be both more diversified and would make on average less ubiquitous products. (p. 311).

The result that more complex economies will be more diversified has been emphasised across the economic complexity literature that has flourished since the original contributions (Tacchella et al., 2012; Cristelli et al., 2013). These works have highlighted the fact that rich countries are also characterized by high diversification of the basket of their internationally traded goods and services. This is counterintuitive to the standard economic approach, particularly the Ricardian paradigm of international specialisation, which predicts that rich countries will be characterised by the production of only a few products with a high degree of specialisation.

This chapter presents how growth and development are conceptualized in the economic complexity framework, which is enshrined in the broad perspectives of heterodox evolutionary theory of development as conceived by Nelson and Winter (1982), Nelson (2008) and Orhangazi (2017). Section 2 defines the concept of capabilities underpinning the economic complexity approach and explores the underlying processes or mechanisms of capabilities accumulation. Section 3 presents the theoretical grounding and analytical tools of economic complexity framework, focusing on its key implications for economic theory on diversification, growth and development. Section 4 introduces the methods for measuring the economic complexity of a country and the products it produces. Section 5 reviews empirical works on the relationship between economic complexity, structural transformation, and growth. In Section 6 we provide some conluding remarks and implications for future research.

4.2. CONCEPT OF CAPABILITIES AND UNDERLYING ACCUMULATION PROCESSES

In their original paper, in which they develop a view of economic growth and development that gives a prominent role to the complexity of a country's economic system, Hidalgo and Hausmann (2009) think of capabilities as the building blocks of economic complexity. However, they do not elaborate on the theoretical grounding of their conceptual approach. This is not surprising. The concept of capabilities emerges from evolutionary theories and strategic management literature that focus on firms' capabilities not only as the driver of their growth, but more importantly, as the immediate cause of industrial development and countries' wealth (Lall, 1992; Sutton, 2002, 2012; Penrose, 1959; Nelson & Winter, 1982; Teece, 2019; Fagerberg & Srholec, 2017; Teece & Pisano, 2003; Sainsbury, 2020). While these scholars have viewed firms as the prime institution in economic development and growth (Teece, 2017), mainstream economics has mostly treated firms as homogeneous black boxes and abstracted from the heterogeneous capabilities that differentiate them. "Economists, until quite recently, have not developed the concept (*capabilities*)" (p.1)

Given the salience of capabilities to economic performance and development policy, it is surprising that economic complexity scholars have only loosely defined the concept of capabilities and devoted less attention to the processes underlying its accumulation or development at both firm and national levels. In the next section, we provide a cursory review of the concept of capabilities to gain essential insights about this driver of economic dynamics.

4.2.1. Concept of Capabilities

The concept of capabilities is ambiguous in economic complexity literature, where it is used interchangeably with the terms 'productive knowledge' and 'know-how.' In the Atlas of Economic Complexity glossary published by Harvard Growth Lab, the term 'know-how' is defined as "the tacit ability to produce a product. Also known as productive capability, know-how refers to productive knowledge that goes into making products.". This definition is extended and clarified as follows:

> Know-how, as tacit knowledge that only exists in brains, stand in contrast to embedded knowledge where all knowledge is held in the technology (e.g. iPhone); and codified knowledge, where all knowledge is explained and detailed in codes or blueprints. Know-how is better conceived as the ability to walk, as tacit knowledge that cannot be fully explained using words, but the knowledge that is the slowest to transfer by requiring time-intensive processes of imitation and repetition. While embedded knowledge (e.g.

iPhones) can be shipped across the world and codified knowledge (e.g. Wikipedia) can be accessed online, we believe it is the slow transfer of know-how that explains the slow, incomplete diffusion of technology and production around the world that stands at the heart of the economic growth process. Policies that aim to speed up the diffusion of or diversify the know-how of a society hold important implications on the pace of economic growth—and its inclusiveness. (Atlas of Economic Complexity).

In Felipe, Kumar et al. (2012), the authors admit that listing all the capabilities might be impossible. Nonetheless, they understand productive capabilities in Hausmann & Hidalgo's theory to specifically refer to the following: (i) "the set of human and physical capital, the legal system, institutions, etc. that are needed to produce a specific product"; (ii) the 'know-how' or working practises held collectively by the group of individuals comprising the firm"; and (iii) "the organizational abilities that provide the capacity to form, manage, and operate activities that involve large numbers of people "(p. 37). Obviously, this a broader concept of capabilities than the one defined in the Atlas of Economic Complexity.

The strand of economic complexity research, led by Luciano Pietronero at Enrico Fermi Study and Research Centre (CREF) in Rome, emphasizes the concept of productive capabilities of a country, which are defined in Sbardella, Zaccaria et al. (2021, p.51) as "the skills that enable its economy to expand into new production requirements and to adopt new technologies" (citing Cimoli et al., 2010; Teece et al., 1997). Thus, for this line of research, the concept of capabilities is more related to its conceptualisation in strategic management and innovation literature. In this conception, productive capabilities are seen as "a set of skills which, in addition to allowing the implementation of the existing technologies, also facilitate the adaptation to new production requirement and stimulate the introduction of new technologies by linking different innovation regimes to different organisational routines" (Sbardella, Zaccaria et al. 2021, p.51, citing Lall, 1992; Kremer, 1993).

In the same line of research, Cristelli et al. (2013) previously conceived capabilities as a country's special fundamental endowment of intangible assets. They represent "all the resources of the economy of the given country and the features of the national social organization making possible the production and the export of the basket of tradable goods by the same country." "These capabilities," they noted, are usually non-tradable goods and are very difficult to measure and compare across countries" (p.5). While these scholars try to capture capabilities at the macro or aggregated level, their concept encompasses what is commonly referred to in strategic management literature as resources (Penrose, 1959).

It is clear from the definitions above that, as used in economic complexity framework, capabilities bear different meanings. As conceived by Hidalgo and Hausmann (2009) and defined in the Atlas of Economic Complexity glossary, the concept of capabilities is not differenced from the individualistic world of the neoclassical approach, “where capabilities are rooted exclusively in the abilities of individuals, or get mixed into an aggregated production function” (Aistleitner et al., 2021, section 2.1). These authors observe that by relating capabilities to ‘knowledge’ or ‘know-how,’ one could simply treat the terms as synonyms and use measures of human capital to implement the capabilities concept. In this narrow and individualistic view, they argue, capabilities are located at the individual level. Such narrow focus simplifies the issue of capabilities development to how a firm and country’s employees or citizens respectively could accumulate more human capital. They forcefully opined that, while many approaches, such as the endogenous growth theory, embed such a conceptualization of capabilities, this is not the most significant, neither for the sustained success of the firm, nor for growth and development on the country level (citing Sutton, 2012, Teece, 2017).

While the stream of literature following Hidalgo and Hausmann (2009) uses the terms ‘capabilities’, ‘productive knowledge’ and ‘know-how’ as synonymous, it certainly does not mean to equate capabilities with human capital. In Hausmann, Hidalgo et al. (2014), the authors argue and empirically demonstrate that the economic complexity approach and other approaches that focus on human capital emphasise different aspects of the same intricate reality. They show that these different approaches do not have the same ability to capture factors that are verifiably important for growth and development – the economic complexity index captures significantly more growth-relevant information than the commonly used indicators of human capital.

As used in Cristelli et al. (2013), the concept of capabilities is broadly defined at the national level. Nevertheless, it is closely related to the resource-based view (RBV) of the firm (Penrose, 1959; Wernerfelt, 1984). By firm’s resources, Wernerfelt means “those (tangible and intangible) assets which are tied semi-permanently to the firm. Examples of resources are: brand names, in-house knowledge of technology, employment of skilled personnel, trade contacts, machinery, efficient procedures, capital, etc. However, as defined and discussed in strategic management literature, the concept of resources is different from that of capabilities, which captures more organisational aspects and arise in part from learning, from combining resources, and from exploiting complementary assets (Teece, 2019).

Although some scholars have strongly argued that capabilities should be seen as being first and foremost properties of firms (and not individuals or countries) (Aistleitner, 2021), others have shown that they may also be used at the level of nations to explain differences in development across countries (Fagerberg & Srholec, 2008; 2017; Lall, 1992; Sutton, 2012). Fagerberg and Srholec (2008) report that, following a series of works by authors who emphasise the crucial role of technology for economic development, concepts such as "social capability" (citing Ohkawa and Rosovsky, 1974, Abramovitz, 1986), "technological capability" (citing Kim, 1980, Kim, 1997), "absorptive capacity" (citing Cohen and Levinthal, 1990) and "innovation system" (citing Lundvall, 1992, Nelson, 1993, Edquist, 1997) have been suggested and emerged in empirical literature.

In his study of the rapid catch-up and rise of Korea, Linsu Kim (1999. p.14) defined technological capability as "the ability to make effective use of technological knowledge in efforts to assimilate, use, adapt and change existing technologies." This includes organised R&D and other capabilities needed for the commercial exploitation of technology. Kim considered three aspects of technological capabilities, namely production capability, investment capability and innovation capability, stressing that innovation capability increasingly become more demanding and harder to develop as countries move up the development ladder.

The concept of social capabilities was used by Abramovitz (1986) when he suggested that differences in countries' abilities to exploit the potential for catch-up may be partially explained by differences in what he called "social capability". According to Fagerberg & Srholec (2008, p.1419), "what Abramovitz meant was not so much individual skills but rather what organisations in the private and public sector are capable of doing and how this is supported (or hampered) by broader societal factors" (p.1419). Some of the aspects of social capability that Abramovitz emphasised as being particularly important include managerial and technical competence, stable and effective government, financial institutions, and markets, spread of honesty and trust in the population.

The economic complexity scholars claim that their approach is agnostic about the nature of factors or determinants of growth (Hidalgo, 2021). In other words, it does not aim to identify individual determinants of growth but to measure combinations of them indirectly by extracting information encoded in the country's productive structure. Pugliese and Tacchella (2021) argue that "looking at 'what a country is able to do' provides a clearer understanding of the underlying *dynamical capabilities* of the national innovation and industrial system (p.4). These statements suggest that the concept of capabilities they have in mind is related to the concept of technological capabilities as used by Kim (1999). While acknowledging that social capabilities are important and inseparable from technological capabilities, we believe that this interpretation has the potential to derive direct policy implications for supporting technological learning and accelerating catch-up in sub-Saharan Africa. It is this interpretation that we adopt in this study when we refer to productive capabilities.

4.2.2. Processes of capabilities accumulation

Economic complexity scholars show that "countries tend to approach the level of income associated with the capability set available in them" (Hidalgo & Hausmann, 2009, p. 10570). However, despite the growing popularity of this approach in macroeconomic development, its proponents have devoted less effort to the question of how firms and countries accumulate capabilities. To derive relevant policy implications for economic growth and development, it is crucial to grasp the processes or mechanisms through which capabilities are accumulated. To this effect, we turn once again to the literature in the fields of strategic management, industrial organisation, and innovation, where capability accumulation (CA, hereafter) has been one of the main research foci for a long time. We provide in this section a brief overview of business and specialised literature on technological capability accumulation, focusing on the aggregate level. A valuable source in this regard is the paper by Aistleitner et al. (2021), which extensively reviews and summarises the most influential theoretical and empirical literature on various determinants and mechanisms of CA.

Macroeconomics models of growth have recognized and attempted to consider CA as an empirically relevant processes, as pointed out by Hidalgo and Hausmann (2009). However, due to data availability issues and the desire to keep the overall complexity of the models manageable, progress in this regard has been limited. Aistleitner et al. (2021) point out that the motivation to develop endogenous growth models was the need to study the role of CA for economic development *endogenously*, rather than treating it as an exogenous factor as was postulated in the standard neoclassical growth models. In the endogenous growth models[15], they point out, CA results from the investment activities of profit maximizing agents, mostly through R&D decisions of the firms, as well as the assumed market environment. However, they note that these models focus on the macroeconomic implications of CA and abstract from most of the learning activities on the firm and employee level. It also abstracts from the heterogeneity of firms in terms of their performance and competitiveness.

To identify the processes of CA, Aistleitner and co-authors look at theory and empirics beyond macroeconomic models. Following a carefully designed strategy, they select and review the 90 most influential papers from different relevant fields focusing on CA. These were mostly published papers in SSCI-ranked journals between 2006 and 2020 and listed in at least one of the WoS categories 'Business', 'Economics' or 'Management'. They present the results of their review of theoretical and empirical literature, identifying key determinants of CA and describing their processes.

The results of the theoretical literature identified seven significant determinants featured in specialised models of CA, all emphasising various aspects of investment in R&D. The first determinant of CA is through patenting, external spillovers, and R&D by firms investing in (innovative and imitative) activities to discover new products that are assembled from different components and can be patented. Models underlying this mechanism highlight the role of intellectual property rights (IPR) in fostering or hampering innovation (citing Marengo et al. , 2012). The second determinant of CA is the organisation of human capital. These models underline the knowledge embodied in each individual worker as the main driver of CA through the mobility and interaction of workers from countries and firms with higher capabilities (citing Dasgupta (2012). The third determinant is the alliances and ACAP through which firms (that aim for a competitive advantage) acquire voluntary and involuntary spillovers, respectively, increasing R&D investment and leading to incremental innovation (citing Savin & Egbetokun, 2016). The fourth determinant is related to the interrelationship of three different mechanisms of CA: R&D investment, alliances, and learning-by-doing on the part of firms that collaborate

[15] Aistleitner et al. (2021, Table 1) provides the building blocks of CA processes in endogenous growth models as considered in seminal papers, citing Romer, 1990; Weitzman (1998); Aghion and Howitt, 1992; Howitt, 2000; Rivera-Batiz and Romer (1991); Grossman and Helpman, 1991a, Acemoglu et al. (2007); Atkinson and Stiglitz (1969), Acemoglu and Zilibotti (2001), Acemoglu (2002b)

on the intra-regional and interregional level to acquire implicit and explicit knowledge. This process leads to increased investment in R&D and CA through knowledge intensification and can be facilitated by public policies (citing Pyka et al., 2019). The fifth determinant of CA is investment in imitation and innovation R&D by firms that move into a technology space to acquire a competitive advantage, with firm size determining the success of innovation and the extent of ACAP (citing Caiani, 2017). The sixth determinant of CA, at the national level, is domestic and foreign R&D investment, inward FDI, and international spillovers. The speed of CA is determined by ACAP (citing Criscuolo & Narula, 2008). The seventh and final determinant of CA identified is related spillovers from investment in R&D by firms aiming at extracting new techniques from a technology space. The extraction is facilitated by spillovers from domestic competitors and accelerated by national policies (citing Landini & Malerba, 2017).

Aistleitner and co-authors also present the results on the determinants of CA at the aggregated and firm levels from the empirical literature. We will focus here on the three main overlapping clusters identified in their paper: (i) the cumulative and path-dependent nature of CA; (2) the institutional environment; and (3) the relevance of government activity (For the summary of the results, see Aistleitner et al., 2021, Table 4E).

First, the studies reviewed underscore the path-dependent nature of CA, which implies that previous capabilities determine the development (path) of future ones. In accordance with the principle of relatedness (underlying the Product Space framework in economic complexity), new capabilities are found to be accumulated stepwise and tend to be like those that have already been accumulated. This has been long recognised by economic complexity scholars (see e.g., Hidalgo, Klinger et al., 2007; Hidalgo & Hausmann, 2009; 2011; Hidalgo et al, 2007). Different papers reviewed highlight various aspects of dependency in the process of CA, linked namely to relatedness to pre-existing capabilities, the country's knowledge base focus, degree of inter-relatedness between technologies, structures causing institutional 'lock-in.' The review draws attention to the fact that path dependency of CA can also explain why countries, regions, or industries fail to sustain CA (citing Brem et al., 2016; De Noni et al., 2017), adding that this might also be one reason for the existence of the 'middle-income trap' (citing Radosevic & Yoruk, 2018, Lee & Malerba, 2018; Gräbner and Hafele, 2020).

Second, most of the reviewed empirical studies stress the relevance of regulatory measures and other institutions for CA at firm, industry, and country levels. Determinants include intellectual property rights (ambiguous), protectionism, economic integration (ambiguous), labour market institutions (ambiguous), socio-political and socio-economic development (inequality, education, health, and public infrastructure), financial development (positive effect) and financial liberalisation policies (negative association with CA). The review reports some disagreements regarding the relative strength and direction of the effects, as well as the underlying mechanisms of institutions. In particular, with respect to economic integration, numerous studies find positive spillover effects caused by trade liberalisation and/or FDI-flows in both developing(citing Castellacci & Natera, 2013), and high-income countries (citing Ascani et al., 2020, Filipescu et al., 2013). Several other studies suggest that the effect of economic integration on CA is driven by various context-specific factors (citing Wu, 2012; Xie and Li, (2018; Radosevic & Yoruk, 2018). Furthermore, while studies agree that financial development is good for CA via R&D spending, financial liberalisation policies are found to have deleterious effects on the CA process — particularly in developing countries (citing Ang, 2010). Finally, the studies highlight the ambiguous role of IPR and labour market regulations in CA.

The third cluster of CA determinants identified in the review is related to government activity. Direct government action was found by numerous studies to be relevant for CA. More entrepreneurial action was found to enhance CA through various channels, including public R&D investment, public ownership and governance of key sectors and enterprises, public procurement policies, and active industrial policies (training programmes, coordination, mediation, and collaboration (e.g. domestic and foreign firms, universities, research institutions) for triggering or fostering CA processes.

4.2.3. Quiescence trap or trap of development stasis

An important concept which has emerged in economic complexity literature to explain lack of economic diversification and growth is that of "a quiescence trap" or trap of development stasis"(Hidalgo & Hausmann, 2011). This concept is used to describe a phenomenon emerging from the cumulative and path-dependent nature of CA, and is similar to a suboptimal lock-in to an inferior capability set reported by Brem, Nylund, & Schuster (2016). In Hidalgo and Hausmann (2011), the authors deviate from the traditional aggregate analysis of GDP and look instead at the structure of output embodied in the network connecting countries to the products that they export, using complex network science (see fig.3.1). They develop a simple modelling framework that can be used to understand and reproduce the global patterns of exports summarised in the binary M_{cp} matrix of the country-product network. The model is based on the assumptions that: (i) products require the combination of a large number of non-tradable inputs, or capabilities, and that countries differ in the completeness of the set of capabilities they have; (ii) countries can only produce the goods for which they have all the required capabilities; and (iii) the probability that a country has a capability and that a product requires a capability is constant. Using relevant mathematical notations and solving the model, they derive important theoretical implications regarding the relationship between the diversity of the products and the diversity of the capabilities. The model predicts that:

As the fraction of capabilities required by the average product increases $(q \rightarrow 1)$, the number of new products that become accessible after accumulating a few capabilities becomes small to negligible for countries with only a few capabilities, while at the same time it becomes extremely large for countries with many of them. This implies that in worlds in which products require a large fraction of the total number of capabilities that exist $(q \rightarrow 1)$, catching up becomes more difficult, since the large fraction of capabilities required by products causes simultaneously, negligible returns for countries with few capabilities and large returns for countries with many of them. (p. 337).

The model, therefore, predicts the existence of a "quiescence trap," or a "trap of development stasis, in which countries with a low diversity of capabilities get stuck. Countries with few capabilities face low incentives for the accumulation of additional capabilities because, in a world in which products require a high fraction of capabilities, they get no returns in terms of diversification for the accumulation of one or two extra capabilities. However, countries with large initial endowments of capabilities will have large returns on the accumulation of any additional ones, since there is a high probability that any new capability that comes along will be use in combination with the capabilities already present in that country. Such countries will find it easier to diversify and produce a mix of products with important positive implications for economic growth (Brummitt et al. 2020).

4.3. THEORETICAL AND ANALYTICAL FRAMEWORK

4.3.1. Theoretical Grounding of Economic Complexity Approach

In their seminal contribution, Hidalgo and Hausman (2009) did not elaborate much on the concept of capabilities which they view as the 'building block' of the economic complexity approach to growth and development. Subsequent works – that attempt to brand economic complexity as a policy-relevant approach to macroeconomic development – trace the concept of capabilities back to the previously mentioned literature on evolutionary theory and strategic management. For example, Pugliese and Tacchella (2020) acknowledge that the economic complexity framework builds on earlier evolutionary and institutional literature (citing Hirschman 1958, Cimoli & Dosi 1995, Teece, et al. 1994). Consistent with Lall (2000) – who saw economic development as an evolutionary process with technological learning at its heart, Pugliese and Tacchella under core that in an attempt to tackle the complexity of the economic system, the economic complexity approach "describes the economy as an evolutionary process of globally interconnected ecosystems. The framework shifts the focus of economic analysis from aggregate quantities, i.e., 'how much' a country makes, to their underlying components, i.e., 'what' a country makes" (p.1). Looking at what a country makes rather than how much it makes, they argue, "is able to provides a clearer understanding of the underlying dynamical capabilities of the national innovation and industrial system" (p. 1).

Likewise, Sbardella, Pugliese et al. (2018) trace back the economic complexity approach to the seminal work of Hirshman (1958) and subsequent contributions from the theory of firm capabilities, strategic management literature, and industrial organisation fields (citing Penrose, 1959; Abramovitz, 1986; Fagerberg, 2017; Lall, 2000; 1992; Kremer, 1993; Sutton, 2002). These works are in the strand of research that have in common the conviction that "one cannot adequately explain the wealth of either firms or nations without a theory of capabilities" (Teece, 2019, p.1). Indeed, this is well articulated in John Sutton's book "Competing in Capabilities", in which he states: 'The proximate cause [of differences in the wealth of nations] lies, for the most part, in the capabilities of firms' (Sutton, 2012, p. 8). This link between a firm's capabilities and the wealth of nations has been reiterated recently by Sainsbury (2020) in the framework of dynamic capabilities when he states that:

> The rate at which a country's economy grows depends critically on whether its firms can build the capabilities to generate and take advantage of "windows of opportunity" that

> exist for innovation and new markets, and whether over time they are able to enhance their capabilities to move into higher value-added activities. (Abstract).

An evolutionary theory of economic activity and change differs in fundamental ways from the neoclassical theory as encapsulated in the growth models analysed in previous chapter (Nelson, 2008). This scholar squarely agrees with Sanjaya Lall who pointed out that standard neoclassical economics was completely inadequate as a theory of what was going on (see e.g. Lall in Kim and Nelson, 2000). He is puzzled and saddened by his colleagues in economics who continue to hold onto a neoclassical growth theory that, in his own terms, "cannot deal adequately with an economic context in which innovation is important." In this paper " Economic Development from the Perspective of Evolutionary Economic Theory," Nelson stresses that:

> only an evolutionary theory fits what is known about how technological learning progresses. It also argues for recognition, right at the basis of economic theorizing, that modern economic systems contain a rich mix of institutions, and not simply the firms, households, and markets, that are in neoclassical theory, and that the roles of government cannot be adequately understood as simply responses to "market failures". It develops a view that long run economic change must be understood as involving the co-evolution of technologies in use and the institutional structures (Abstract).

Drawing on empirical research during the 1950s and 1960s on the sources of macroeconomic growth - which firmly established that technological advance was the key driving force – as well as on the rediscovery of the features of economic activity where innovation was important (see Schumpter, 1934, 1950), the evolutionary economics has built an alternative growth and development theory that . explains what actually is happening in economic activity change (see Nelson & Winter, 1982; Nelson, 2008; Orhangazi, 2017), Such theory is not only able to make sense out of the aggregate time series of output and aggregate inputs as in the neoclassical growth models, but it also " able to illuminate the important details of growth, qualitative as well as quantitative, that one sees in the accounts of economic historians" (Nelson, 2008, p.18).

Building on the broad foundation provided by an evolutionary theory, 1the economic complexity framework departs from the analysis of cross-country differences in economic growth. This analysis has traditionally focused on the study of aggregate output under the assumption that goods produced in different economies are fundamentally identical. Economic complexity scholars point out that the assumption of identical goods and services is problematic (Hidalgo & Hausmann, 2011). They argue that, as evidenced by previous attempts to develop growth models with many goods that differ in some fundamental way based on Dixit-Stiglitz production function (citing Grossman & Helpman,1991; Aghion & Howitt, 1992), products are not the same. There is something intrinsically different about the sets of products that various countries make.

Deviating from the aggregated-based modelling of growth, the economic complexity framework looks instead at the structure of output embodied in the network connecting countries to the products that they export to identify the capabilities endowment of an economy. Contrary to the mainstream approach in economics, which tackles the growth modelling problem by going from inputs to final output in the attempt to identify significant determinants of growth among a myriad of variables, the economic complexity approach uses methods from complex network science to reduce the dimensionality of the space embedding economic dynamics; it goes in the opposite direction from final output to inputs or endowments. As put, it by Cristelli, Tacchella, Cader, et al. (2017), "It is the set of produced products that informs on the capabilities of a country and its potential competitiveness in a compact description" (p.8). The application of dimensionality reduction techniques to data preserves more information about what countries produce. This information, which would otherwise be lost in mere aggregates, is important for our understanding of growth and development. Obviously, and as rightly recognised by Pugliese &Tacchella (2021), this shift creates the opportunity of impacting several cross-cutting themes and answering quantitatively several policy-relevant questions that could otherwise only be answered qualitatively, in specific case studies, or by ad hoc metrics.

It is worth nothing that the focus of analysis in the economic complexity framework differs significantly from the mainstream approach to economic growth in other important ways. Unlike conventional growth models, the economic complexity approach is agnostic about the nature of factors or determinants of growth (Hidalgo, 2021). In other words, it does not aim to identify individual determinants of growth but to measure combinations of them indirectly from the data. As argued by Pugliese and Tacchella (2021), "looking at what a country is able to do provides a clearer understanding of the underlying dynamical capabilities of the national innovation and industrial system". To export or successfully patent in advanced industries, they add, "is an unambiguous signal of an advanced economy" (p.4).

In practice, the economic complexity approach defines an economic level encoding the relevant capabilities and a decoding framework to end up with a few new indicators (i.e. few dimensions). Specifically, and as emphasised in Zaccaria et al. (2014), the economic complexity framework "pinpoints the productive system as the level which reflects the complete information about capabilities: the capabilities themselves and their interactions" (p.4). Thus, country productive structure, defined on a competitive basis, is proposed as a proxy that carries information about the capabilities owned by a country (Cristelli, Tacchella, Cader et al., 2017) – "it is the set of products produced and exported by a country that informs on the capabilities it has available" (p.8). For Hartmann et al. (2017, p. 76), "productive structures can be understood as a proxy of an economy's level of social capital and the health of institutions, since the ability of a country to produce sophisticated products also critically depends on the ability of people to form social and professional networks (citing Fukuyama, 1996; Hidalgo, 2015).

4.3.2. Analytical Tools and Development Implications

In order to extract relevant information about the structural patterns and dynamical properties of complex economic systems, the economic complexity approach applies complex network theory as the main mathematical tool for the description and representation of these systems (Zaccaria et al., 2014). According to Mariani et al. (2019), "a network representation of a complex system simplifies its analysis by describing it – in the simplest portrayal – as a collection of nodes and links connecting them"(p.1). The underpinning assumption is that "while the obtained network represents a simplification of the complex system it was derived from, it carries enough information to allow us to understand the functioning of the system and the emergence of collective phenomena from the interactions of its constituents" (p. 1).

Cristelli et al. (2013) show that it is possible to represent schematically the economic complexity framework in terms of a tripartite country-capability-product network in which capabilities are the intermediate layer between countries and products (see Fig. 3.1). As already seen in the introductory section of this chapter, the resulting observed bipartite country-export network (right panel) is interpreted as the result of a projection of a tripartite country-capability-product network where countries are connected with the capabilities they possess and products are connected with the capabilities they require in order to be produced.

In Zaccaria et al. (2014), the authors argue that "the time series of exports gives a fundamental insight to understand countries' development, and can help define an empirical framework to assess the validity of theoretical paradigms"(p.2). They show that, while it is not possible for countries to directly trade capabilities, it is the specific combination of those capabilities that results in various products traded. Countries with more capabilities reaps higher returns and the accumulation of new capabilities provides an exponentially growing advantage. Therefore, they conclude, "the origin of the differences in the wealth of countries can be inferred by the record of trading activities analysed as the expressions of the capabilities of the countries" (p.2).

Assuming that products are defined by means of the set of capabilities which are needed for a country to be able to produce them, one can use export data between trading partner countries to empirically build a network connecting countries to the products they export. In this country-product network, exports of countries can be informative about capabilities; that is, an observation of a country's export of a given product can tell us about the presence of specific capabilities. Hausmann and Hidalgo (2009) leveraged this intuition to build a model of world trade where a given country exports a given product if and only if the country possesses all the capabilities required to produce that product. In practice, and as rightly recognised by Mariani et al. (2019), this model can be considered a ''neutral model'' of development in a similar spirit to neutral models in ecology: "the interactions driven by a hidden property – species abundance and country capabilities in ecological and trade networks, respectively – might explain the network's structural patterns and, in particular, its nestedness"[16] (p.3).

Using graph theory, the country-product bipartite network derived in fig.3.1 can be mathematically represented using a bipartite graph. A bipartite graph is a triple G = (A, B, E) where $A = \{a_i \mid i = 1 \ldots n_A\}$ and $B = \{b_j \mid j = 1 \ldots n_B\}$ are two disjoint sets of vertices or nodes, and $E \subseteq A \times B$ is the set of edges or links, i.e., edges exist only between vertices of the two different sets A and B (Caldarelli et al., 2011). The bipartite graph G is described by a binary matrix M, defined as:

$$M_{i,j} = \begin{cases} 1, & \mathit{if\ an\ edge\ or\ link\ exists\ between}\ \text{ai and bj} \\ 0, & \mathit{otherwise} \end{cases} \tag{4.1}$$

In terms of a bipartite trade network, a binary country-product matrix M can be defined with elements M_{cp}, indexed by country c and product p (Hausmann et al., 2009). $M_{cp} = 1$ if country

[16] Informally speaking, "nestedness refers to a hierarchical organization where the set of neighbors of a node is a subset (superset) of the neighbors of lower (larger) degree" (Mariani et al., 2019, p.2).

c is competitive or has a revealed comparative advantage (RCA) > 1 in product p, where RCA is calculated using the Balassa index (Balassa, 1965), given by:

$$RCA_{cp} = \frac{X_{cp}}{\sum_p X_{cp}} \Big/ \frac{\sum_c X_{cp}}{\sum_{cp} X_{cp}}, \tag{4.2}$$

where X_{cp} is country c's exports of product p. $M_{cp} = 0$ otherwise.

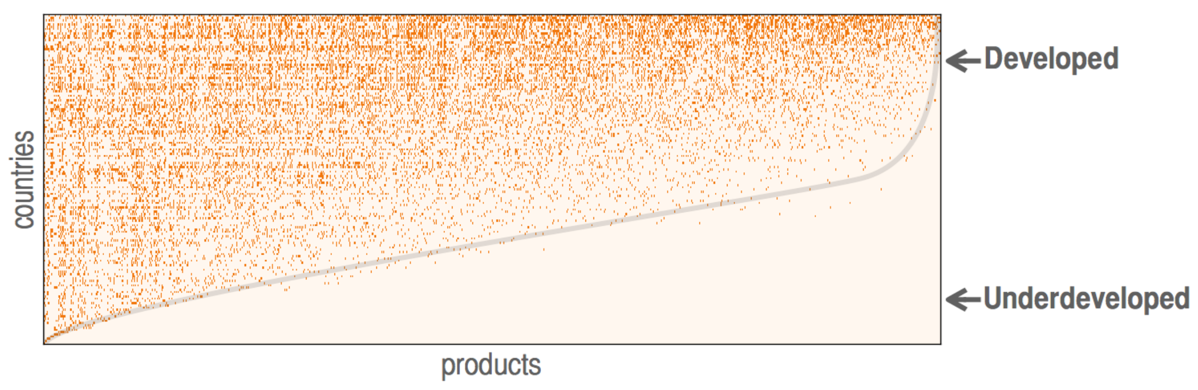
Considering countries and products as vertices or nodes of a network, one can pictorially say that the node of the country c is linked to the node of the product p if $M_{cp} = 1$. Since links are not permitted between two countries or two products, the matrix M defines a bipartite country-product network. This means that the nodes are divided into two sets: {c} of N_c nodes (countries) and {p} of N_p nodes (products). Links are permitted only between couples of nodes belonging to different sets (see Cristelli et al., 2013).

The representation of complex systems through the use of graph theory has allowed economists to apply the methods and tools from complex network science to the world trade network and derive significant science-grounded implications for the patterns of countries 'growth and development (see e,.g., Cristelli et al., 2013; Cristelli, Tacchella, & Pietronero, 2015; Cristelli, Tacchella, Cader et al.,2017; Hartmann et al., 2017; Hausmann, Hidalgo et al., 2014; Mealy et al., 2018; Tacchella et al., 2012).

In Caldarelli et al. (2011), the authors made fundamental observation on the structure of the country-product network matrix, with significant implications for economic theory. They observe that when the bipartite network matrix Mcp is written by ordering the lines progressively from the country exporting the largest number of products to the country exporting the lowest number and correspondingly the columns from the most to the less exported product, it assumes a triangular structure. This means that "some countries export a large fraction of all products (highly diversified countries), and some products appear to be exported by most countries (ubiquitous products)"(p.1).

This can be seen through the visualization in Figure 3.2, which reveals a clear statistical feature of "nestedness," a key property of complex ecosystems which are both adaptive and evolutionary and where actors compete for finite resources. "An economic system is said to be nested when specialist (non-diversified) countries tend to produce a subset of products which is also made by generalist (diversified) countries; on the other hand only generalist (ubiquitous) products are produced by specialist countries (Cristelli, Tacchella, Cader et al., 2017, p.9, citing Dominguer-Garcia et al, 2015).

Figure 4.2. The nested structure of the binary bipartite network



Notes: "Rows represent country export baskets and columns instead specify products. A dark orange dot means that Mcp =1 while light orange means Mcp =0. Rows and columns are rearranged according to Fitness and Complexity dimensions" [Source: Cristelli, Tacchella, Cader et al., 2017, p.10]

According to the economic complexity scholars (e.g., Bustos et al., 2012; Caldarelli et al., 2011; Cristelli et al., 2013), the nestedness property of the country-product network has profound implications for economic theory. It implies a significant departure from the patterns of countries 'specialization and development suggested by the standard comparative advantage theory of Ricardo (1817). This theory predicts that countries benefit from specialising in the products on which they have a comparative advantage. Moreover, based on the found U-shape relationship between metrics for country diversification and income, Imbs and Wacziarg (2003) claimed that ''poor countries tend to diversify, and it is not until they have grown to relatively high levels of per capita income that incentives to specialise take over as the dominant economic force'' (p.83). However, as shown by the nestedness property of the world trade network, the most developed countries are highly diversified: they exhibit diverse export baskets by having a revealed comparative advantage over many products. By contrast, developing countries are only competitive in the export of ubiquitous products that are also exported by highly diversified countries.

Worth noting, the nested structure of the country-product bipartite network suggests that the diversity of a country's production underpins its growth and development. This is supported by Tacchella et al. (2012) who find that "successful countries are extremely diversified, in analogy with bio systems evolving in a competitive, dynamical environment" (p.1). Using a machine-learning-based method, a recent study by Brummitt et al. (2020) reports findings suggesting that diversification drives economic development. More specifically, these authors find that: (i) "what most distinguishes countries' export baskets is their diversity, with extra weight assigned to more sophisticated products"; (ii) "the pattern of economic development of countries is dominated by a tendency toward increased diversification; economies appear to become richer after they diversify (i.e., diversity precedes growth)" (p. 2). This paper, therefore, wipes out any residual doubt regarding the leading role of diversification as a predictor of economic growth.

The economic complexity research has also challenged the view of economic growth, in which "countries do not need to worry about what they make but rather how much they get out of it" . This long-held view of mainstream economic theory is not consistent with empirical observations (Hausmann, Hwang, & Rodrik, 2007; Hidalgo, 2009). These scholars argue that "what a country produces matters more than how much value it extracts from its products." (Hidalgo, p.2), For instance, this author points out that countries, such as South Korea and Taiwan, that have been able to sustain high growth and move into prosperity, have done so by diversifying their export baskets into products that are different from the ones exported by economically straggling countries such as Venezuela and Nigeria, despite they generated enormous revenues from mineral fuels and natural resource exports. The difference in development results here is explained by the fact that the sets of products that these countries make are intrinsically different; manufacturing goods made by South Korea and Taiwan are not identical to natural resources.

In Hausmann et al. (2007), the authors argue and provide empirical evidence that what a country produces and exports matters for subsequent economic performance; that is, "some products may be more important and beneficial for economic performance than others" (p. 2). What you export matters because "some traded goods are associated with higher productivity levels than others and countries that latch on to higher productivity goods will perform better" (p.2); it also matters because a country's production of certain products reveals its possession of certain capabilities, which are relevant for economic development (Hidalgo & Hausmann 2009; Petralia, Balland, & Morrison, 2017). Based on these empirical observations, Hidalgo (2009) emphasises an important lesson that emerges from the economic complexity research: that "in the long run, the income of countries is determined by the variety and sophistication of the products they make, rather than the trade value of their exports. Countries become what they make" (p.2).

The significance of the economic complexity approach to development economics has been its ability to analyse the implications of countries 'productive structures for long-term growth. By interpreting trade data as a bipartite network in which countries are connected to the products they export and by leveraging complex network algorithms to characterise the structure of this network, the economic complexity approach has been able to develop metrics of productive structure complexity and show that these are successful in explaining differences in economic development across countries and in predicting economic growth (Hausmann & Hidalgo 2009; Tacchella et al., 202); Caldarelli et al., 2011; Hausmann, Hidalgo et al., 2014; Cristelli et al., 2017]. These studies develop and empirically validate a theoretical model showing that the economic complexity of an economy is correlated with the income per capita that a country can generate and that deviations from this relationship are predictive of future growth.

4.4. ECONOMIC COMPLEXITY METRICS

In their paper "Reconciling contrasting views on economic complexity", Sciarra et al. (2020) starts off with a famous quote from the French politician and gastronome, Jean Anthelme Brillat-Savarin, who wrote in his book '*Physiologie du goût'*: "Tell me what you eat, and I will tell you who you are" (p.2). This quote emphasizes an evident truth well familiar to nutritionists on the fact that people's food baskets determine their health status. In the same vein, Sciarra and co-authors use this analogy to show that metrics of economic complexity aim at defining the socio-economic status of countries based on their export baskets. Exports encode the relevant information on the productive capabilities imbedded in a country's economic system; they are a robust proxy for domestic production (Cristelli et al. 2013; Saltarelli et al., 2020).

This section presents metrics of economic complexity and relatedness which have become popular in development economics, thanks to the introduction of complex network theory to the study of emerging economic phenomenon. Relatedness emerged in the context of study of country's productive structure and "is tied to the idea of absorptive capacity — the notion that a firm's ability to absorb new knowledge is a function of its prior level of related knowledge" (Hidalgo, 2021, p.95). Metrics of economic complexity were developed using dimensionality reduction methods on international trade data to quantify the complexity of a country's economy as reflected in the capabilities embodied in its productive structure.

4.4.1. Economic Complexity Index

In order to infer information about countries' productive capabilities from their export baskets, a pair of measures known as the Economic Complexity Index (ECI) and the Product Complexity Index (PCI) have been introduced (Hidalgo & Hausmann, 2009) and improved upon (see, e.g., Albeaik et al., 2015; Brummit et al., 2020; Sciarra et al., 2020: Servedio et al., 2018; Tacchella et al., 2012). Intuitively, Hidalgo & Hausmann (2009) create indirect measures of the capabilities available in a country by thinking of each capability as a building block or Lego piece. In this analogy, a product is equivalent to a Lego model, and a country is equivalent to a bucket of Legos. Accordingly, the question of economic complexity is equivalent to asking "whether we can infer properties such as the diversity and exclusivity of the Lego pieces inside a child's bucket by looking only at the models that a group of children, each with a different bucket of Legos, can make" (p.10570). They show that this is possible if one interprets data connecting countries to the products they export as a bipartite network and assumes that this network is the result of a larger, tripartite network connecting countries to the capabilities they have and products to the capabilities they require.

In Hidalgo and Hausmann technically developed and improved a method to characterise the structure of bipartite networks, which they call the "Method of Reflections", and applied it to trade data to illustrate how it can be used to extract relevant information about the availability of capabilities in a country. They interpret the variables produced by this as indicators of economic complexity that estimate the productive knowledge available e in an economy. Considering the structure of the network defined by the binary matrix M_{cp} and summing across the rows and columns of this matrix, the Method of Reflections consists of iteratively calculating the average value of the previous-level properties of a node's neighbours and is defined as the set of observables:

$$k_{c,N} = \frac{1}{k_{c,0}} \sum_p M_{cp}\, k_{p,N-1} \qquad (4.3)$$

$$k_{p,N} = \frac{1}{k_{p,0}} \sum_p M_{cp}\, k_{c,N-1} \qquad (4.4)$$

for $N \geq 1$. With initial conditions given by the degree, or number of links, of countries and products.

$$k_{c,0} = \sum_{p} M_{cp} \, , \tag{4.5}$$

$$k_{p,0} = \sum_{c} M_{cp} \, , \tag{4.6}$$

$k_{c,0}$ and $k_{p,0}$ represent, respectively, the observed levels of diversification of a country (the number of products exported by that country), and the ubiquity of a product (the number of countries exporting that product). Diversity and ubiquity are, respectively, crude approximations of the variety of capabilities available in a country or required by a product (Hausmann, Hidalgo et al., 2014).

To generate a more accurate measure of the number of capabilities available in a country, or required by a product, we need to correct the information that diversity and ubiquity carry by using each one to correct the other. This is done by "applying the self-referential Method of Reflections algorithm, which first calculates diversity and ubiquity and then recursively uses the information in one to correct the other." Therefore, additional higher-order elements for each country $\vec{k}_N$= (*k*c,0, *k*c,1, *k*c,2 . . . *k*c,N) and product $\vec{k}_p$ = (*k*p,0,*k*p,1,*k*p,2, . . . ,*k*p,*N*) are generated by iterative sequences. Substituting equation () into equation () to eliminate the expression for $k_{p,N}$, yields the following result.

$$k_{c,N} = \sum_{c"} \left(\frac{1}{k_{c,0}} \sum_{p} M_{cp} \frac{1}{k_{p,0}} M_{c'p} \right) k_{c',N-2} \tag{4.7}$$

We can write this as a matrix equation.

$$\vec{k}_N = \boldsymbol{W}.\vec{k}_{N-2}, \tag{4.8}$$

Where the matrix W has elements $W_{cc'} = \frac{1}{k_{c,0}} \sum_p M_{cp} \frac{1}{k_{p,0}} M_{c'p}$

$\vec{k}_N$ represents a vector of country values $k_{c,N}$.

If we take n to infinity, equation (3.6) leads to the distribution, which remains fixed up to a scalar factor: $\boldsymbol{W} * \vec{k}_{.} = \boldsymbol{\lambda}\,\vec{k}_{.},$

Therefore, $\vec{k}$ is an eigenvector of $\boldsymbol{W}$**.** The economic complexity index is defined as the eigenvector corresponding to the largest eigenvalue of the $\boldsymbol{W}$ matrix. In standardized form**,** the Economic Complexity Index (ECI) is given by:

$$ECI_c = \frac{K_c - \bar{K}}{std(K)} \tag{4.9}$$

where K_c is the eigenvector of $\boldsymbol{W}_{cc'}$ associated with the second largest eigenvalue. $\overline{K}$ represents an average; $std(K)$ is the standard deviation.

Analogously, because of the symmetry of the problem, PCI can be defined simply by exchanging the index of countries (c) with that for products (p) in the definitions above. Hence, we define the standardised product complexity index as:

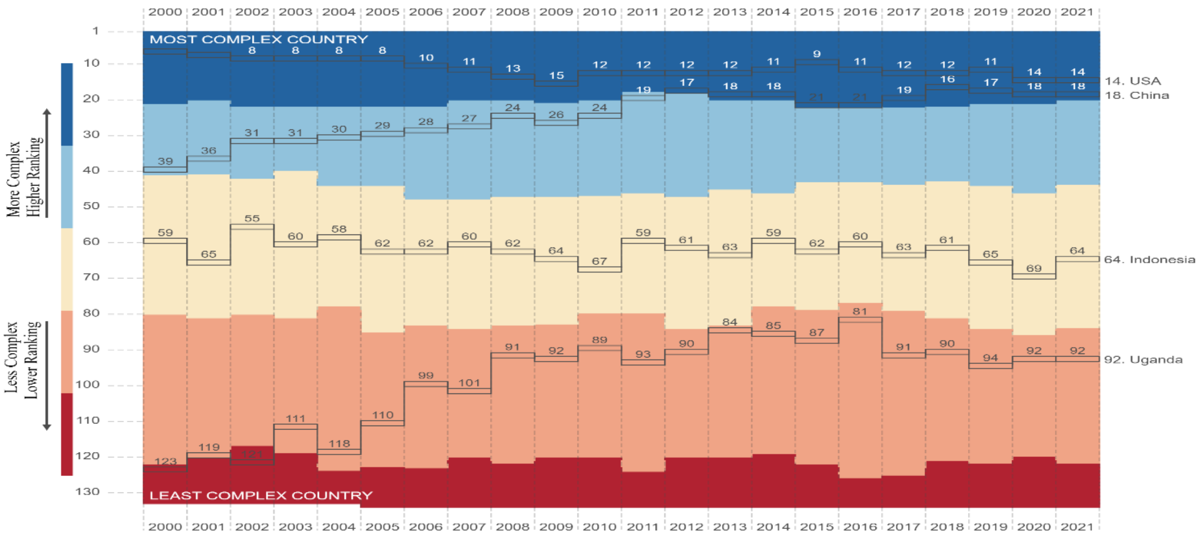
$$PCI_p = \frac{Q_p - \bar{Q}}{std(Q)} \quad (4.10)$$

where Qp = Eigen vector of $W_{pp'}$ associated with the second largest eigenvalue.

The ECI has been initially interpreted as a direct measure of how diversified and complex the export basket of a country is. It reflects how diversified and complex the amount of productive knowledge or capabilities available in a country is. Countries that are home to a great diversity of productive knowledge, particularly complex specialized knowledge, can produce a great diversity of sophisticated products. The PCI captures the amount and sophistication of knowledge required to produce a product. The most complex products include sophisticated machinery, electronics, and chemicals, as compared to the least complex products, which include raw materials and simple agricultural products. Complex products require a range of knowledge in manufacturing, including the coordination of a range of highly skilled individuals' knowledge (Hausmann, Hidalgo et al., 2014).

Both ECI and PCI are used to provide the ranking of countries and products, respectively, according to the complexity of their economies and the sophistication of knowledge they require to produce them. For example, the Atlas of Economic Complexity at Harvard Growth Lab uses visualization tools to (i) determine a country's ECI ranking, (ii) assess a country's change in ECI since 1995 and (iii) compare a country's ranking vis-à-vis other countries. We present in figure 4.3.an illustration of economic complexity ranking extracted from the Atlas of Economic Complexity. showing the most complex countries with higher rankings and the least complex countries with lower rankings. Out of 130 countries ranked in 2021, the USA and China are respectively 14th and 18th in the group of most complex economies. Indonesia is ranked 64th and is in the intermediary group, whereas Uganda is ranked 92nd among the less complex economies.

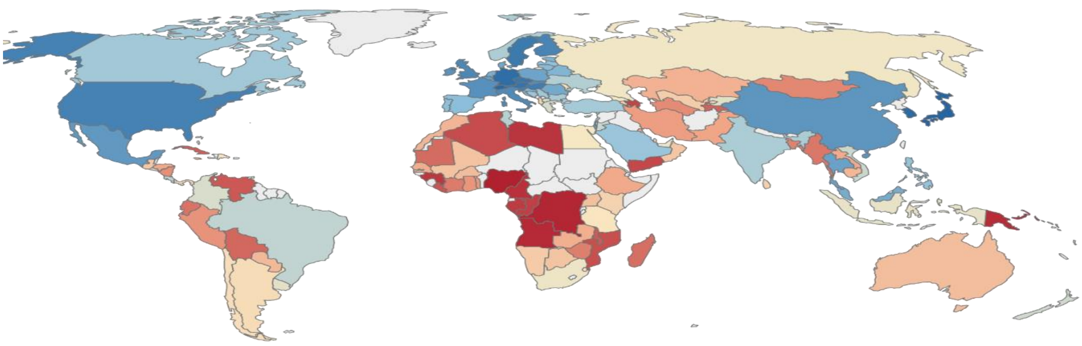
Figure. 4.3. Economic complexity rankings



Source: Atlas of Economic Complexity, Harvard Growth Lab

The economic complexity mapping by geographic location can also be visualized as in figure 4.4. Countries with high economic complexity index are located in North America, Southeast Asia and Western Europe. Africa, in particular SSA, is home to countries with less complex economies in terms of knowledge and capabilities embedded in their productive structures.

Fig. 4.4. Economic Complexity mapping by geographic location



Source: Atlas of Economic Complexity, Harvard Growth Lab (https://atlas.cid.harvard.edu/rankings)

We can also select countries and compare the evolution of their ECI ranking, as shown in figure 3.5. Selected sub-Saharan resource-rich economies are among the least complex, with lower rankings, whereas resource-poor countries in the region rank relatively higher. Emerging economies in Asia, such as South Korea and China, are in the world top ranked countries, while others are in the intermediary group (Vietnam).

__Figure 4.5. Economic complexity ranking comparison__

Source: SoAtlas of Economic Complexity, Harvard Growth Lab

The economic complexity of a country is connected to the complexity of the products that it produces and exports. The Product Complexity Index (PCI) is also used to rank the products that countries produce and export according to the diversity and sophistication of the productive knowledge required to produce each product. Products with a high PCI value (the most complex products that only a few countries can produce) include electronics, chemicals, and machines. Products with a low PCI value (the least complex product that nearly all countries can produce) include raw materials and simple agricultural products.

The Atlas of Economic Complexity and the Observatory of Economic Complexity (OEC) use export data classified according to the Harmonized System (HS) to compute PCI and rank over 1200 categories of products. Table 1 below presents the 10 most complex products with higher rankings and the 10 bottom products out of 1030 for which data are available in 2019. The toppest ranked products, those that require complex knowmedge and capabilities to produce, include Developed Exposed Photographic Material, metal working transfer machines, etc. The bottom ranked products, that is the less sophisticated products that require less complex know-how and capabilities in order to be produced, include crude petroleum, raw cotton, aluminium ore, coconuts, Brazil nuts and cashews.

Table 4. 1. ***Product Complexity Rankings (PCI)***

Rank	Product Nomenclature	HS4 Code	PCI
Topmost Complex Products (Higher Ranking)			
1	Developed Exposed Photographic Material	3705	2.781
2	Metal Working Transfer Machines	8457	2.424
3	Photo Lab Equipment	9010	2.259
4	Disc Chemicals for Electronics	3818	2.186
5	Photographic Chemicals	3707	2.132
6	Machinery Having Individual Functions	8479	2.056
7	Tool Plates	8209	2.037
8	Metalworking Machines	8461	2.033
9	Photographic Film	3702	1.960
10	Cermets	8113	1.942
Bottom Less Complex Products (Lower Ranking)			
1021	Cocoa Beans	1801	-2.459
1022	Ground Nuts	1202	-2.478
1023	Gold	7108	-2.518
1024	Tin Ores	2609	-2.550
1025	Insect Resins	1301	-2.554
1026	Chromium Ore	2610	-2.625
1027	Coconuts, Brazil Nuts, and Cashews	0801	-2.626
1028	Aluminum Ore	2606	-2.672
1029	Raw Cotton	5201	-2.814
1030	Crude Petroleum	2709	-2.831

Source*: Observatory of Economic Complexity (https://oec.world/en/rankings/pci/hs4/hs92)*

The initial interpretation of the ECI - as a direct measure of how diversified and complex the export basket of a country is - has been challenged in subsequent research. In Mealy et al. (2018), the authors show that the standard economic complexity measures (ECI and PCI) are mathematically equivalent to a spectral clustering algorithm that partitions a similarity graph into two parts; they are also related to various dimensionality reduction methods and can be interpreted as vectors that determine distances between nodes based on their similarity. This interpretation, they point out, contrasts with previous conceptual descriptions of the economic complexity measures, which tended to frame the ECI as being related to the diversity of products a country can export competitively. They demonstrate that not only is the ECI mathematically orthogonal to diversity, but it also captures unique, economically insightful information that diversity does not make apparent. Their results illustrate that, when applied to export data, the ECI and PCI reveal a striking pattern of specialisation across countries: High ECI countries (which tend to be richer) specialise in high PCI products, while countries with low ECI (which tend to be poorer) specialise in low PCI products. Thus, "while diversity provides information about how many products countries are competitive in, the ECI and PCI shed light on what type of products high- and low-income countries specialize in" (p.3).

Several papers have also countered the assumption of a linear relation between the products' and countries' complexities and shown that the ECI measure does not take into consideration the important role of diversification, even though this was proposed as one of the motivations for the introduction of ECI (see e.g., Cristeli et al., 2013; Pietronero et al., 2019; Tacchella et al., 2012]. This scholarship shows that the Method of Reflection approach uses a linear algorithm that derives a country's economic complexity as the average of the complexities of the products in its export basket, and a product's complexity as the average of the complexities of the countries exporting it. Thus, as an effect of taking the averages, the obtained complexity measures turn out to lose information about countries' diversification and products' ubiquity. This also leads to completely unrealistic results in terms of countries ranking, as, for instance, the derivation that Qatar or Saudi Arabia are industrially more competitive than China (Pietronero et al., 2019). Consequently, these authors advocate for the use of improved metrics such as the ECI+ (Albeaik et al., 2017), the complexity-weighted diversification (Brummitt et al., 2020), or, more favourably, the novel pair of metrics—the fitness of countries F_c and the complexity of products Q_p—introduced by Tacchella, Cristelli et al. (2012). In the latter approaches, products' complexity non-linearly depends on the complexity/Fitness of the exporting countries, and countries' complexity and fitness preserve information on the diversification of the export baskets (Mariani et al., 2015; Morrison et al. 2017).

4.4.2. Dynamics of economic complexity: Product Space and Relatedness metrics

4.4.2.1. Product Space

In Hidalgo and Hausmann (2009)'s interpretation, the economic complexity of a country reflects the amount of productive knowledge or capabilities embedded in its economic system. But how do economies increase the amount of productive knowledge embedded in them? What limits the speed of this process? Why does it happen in some places but not in others? Several research papers contributed to developing a novel framework to adequately address these questions (e.g., Hausmann & Klinger, 2006; Hausmann, Hwang, & Rodrik, 2007; Hidalgo et al., 2007). These scholars show that new capabilities will be more easily accumulated if they can be combined with others that already exist. Thus, countries are more likely to move into products that make use of the capabilities that are already available. Using the example of shirts and engines, they show that it is easier to move from shirts to blouses than it is to move from shirts to engines because, in terms of embedded knowledge, shirts are more like blouses than to engines. Thus, this scholarship emphasises the path-dependency nature of capability accumulation according to the relatedness principle discussed in Section 3.2.2. A natural implication of this observation is that "[C]ountries will diversify by moving from the products they already produce to others that require a similar set of embedded knowledge" (Hausmann, Hidalgo et al., 2014, p.44).

However, Hidalgo et al. (2007) recognise that measuring the similarity in the capability requirements of different products is not simple, as it would involve collecting a mind-boggling volume of information. Using the example above, they reason that if shirts require knowledge that is similar to that required by blouses but different from that required by engines, then the probability that a country exporting shirts will also export blouses will be higher than the probability that it will also export engines. On this basis, they conclude that the probability that a pair of products are co-exported carries information about how similar these products are. They use this idea to measure the *proximity* between all pairs of products exported around the world. The collection of all proximities constitutes a network connecting pairs of products that are significantly likely to be co-exported by many countries. They refer to this network as the "product space" and show that it can be used to study the productive structure of countries.

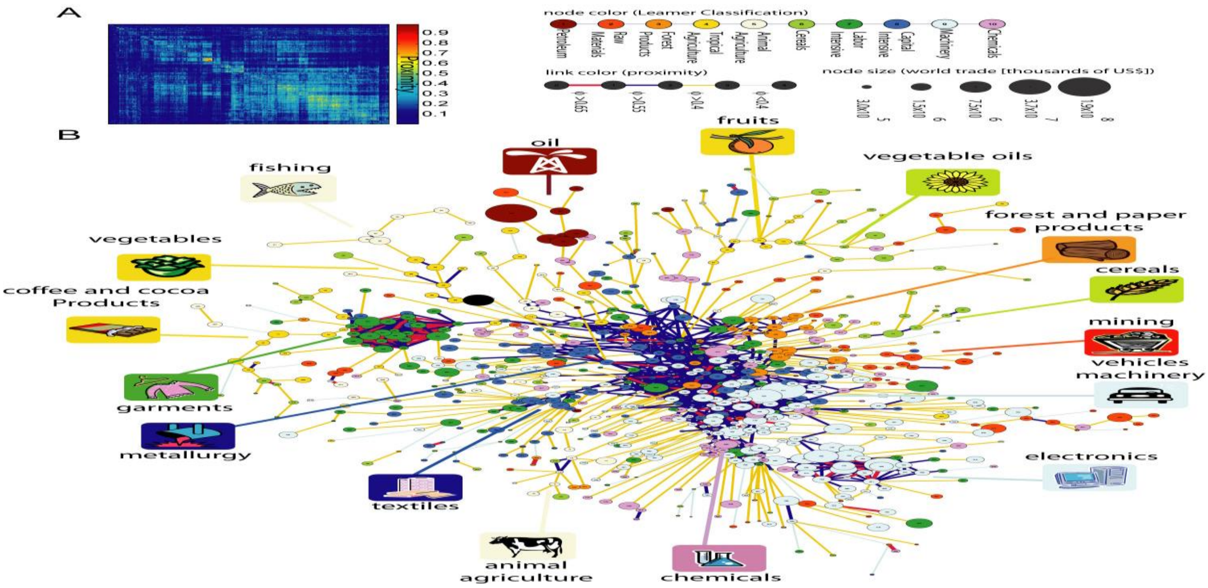
Closely related to the concept of economic complexity, "the Product Space is a network that connects products based on the probability that countries export them in tandem, by assuming that similarities in the capability requirements of products are expressed through co-exports" (Hidalgo, 2009, p.3). While many possible factors may cause relatedness or similarity between products, Hidalgo et al. (2007) use an outcomes-based measure based on the idea that "[I]f two goods are related because they require similar institutions, infrastructure, physical factors, technology, or some combination thereof, then they will tend to be produced in tandem, whereas highly dissimilar goods are less likely to be produced together (p. 2).

More formally, Hidalgo and co-authors use a measure of similarity between products i and j based on the conditional probability of having revealed comparative Advantage(RCA), which measures whether a country is an effective exporter (RCA>1) of a given good i or not (RCA ≤1) given that the country has comparative advantage in good j at time t, and vice versa. They take the minimum of the pairwise conditional probabilities to have a stringent and symmetric measure:

$$\phi_{i,t,j} = \min\{P(RCAx_{i,t} \mid RCAx_{j,t}),\ P(RCAx_{j,t} \mid RCAx_{i,t})\} \qquad (3.9)$$

To calculate these probabilities, they use international trade data disaggregated according to the Standardised International Trade Code at the 4-digit level (SITC-4), providing for each country the value exported to all other countries for 775 products. They calculate the 775 by 775 matrix of revealed proximity between every pair of goods using the equation above.
Applying the tools of complex network analysis, tow a hierarchically clustered version of the matrix and visualise the product space as maps of relative product proximities in which all 775 products are part of a single network. In this network, products are linked by their proximity to each other, based on the probability of their co-export (Figure 3.6).

Figure 4.6. The product space and Leamer clusters



Source: *Hidalgo et al. (2007).* ***A.*** *"Hierarchically clustered proximity matrix representing the 775 SITC-4 product classes exported in the 1998-2000 period.* ***B.*** *Network representation of the product space. Nodes represent products and their size is proportional to total world trade in that good. Links connect products with a high probability of being co-exported. This network was laid out using a force spring algorithm.'*

Scholars have been able to map a country's location in the product space of its export basket to explore the patterns of structural transformation and define paths to industrial diversification. In Hidalgo et al. (2007), the authors empirically demonstrated that countries tend to diversify towards products that are nearby in the product space - "they move from things they know how to do to things that are nearby or related", or what they call the "adjacent possible". Further, they found that countries' export structure and relative position within the product space explain differences in growth performance in a cross-section of countries. Thus, they propose a country's current position within the product space as a leading indicator of its development prospects. This proposition is supported by research from other papers, which find that, depending on the position of a country in the product space at a given time, there are more or fewer paths to structural transformation (Caldarelli, 2012; Hausmann, Hidalgo et al., 2014). This is consistent with the analysis in Hausmann and Klinger (2006b) who previously showed that the heterogeneous structure of the product space has important implications for the speed of structural transformation. They found that countries differ widely in terms of their position in the product space, with some in a sparsely populated part while others are in a much more densely populated section of the product space. Products at the periphery require know-how that is less readily redeployed into many new industries, and countries that specialise in producing and exporting them will find it difficult to structurally transform their economies. "The speed of structural transformation is higher in countries which happen to start in products that are in a denser part of the product space" (pp. 19-20).

4.4.2.2. Relatedness Metrics

A metrics assessing the overall position of a country in the product network is the economic Complexity Outlook Index (COI) proposed by Hausmann et al. (2014). This metrics captures the connectedness of an economy's existing capabilities to drive easy (or hard) diversification into related complex products. To compute COI one first needs to calculate the proximity between two products in the product space network and the distance of every product to existing products in the export basket (from 0 to 1). Proximitiesare calculated based on the notion that if many countries exporting one product are simultaneously able to export another, these two products must rely on many complementary capabilities (hidalgo et al. (2007). Formally, the proximity of two products i and j, $\phi i,j$, is the minimum between the probability that countries export i given they already export j and the probability that countries export j given that they already export i:

$$\Phi pp' = \min \{P (Mcp'= /Mcp' = 1), P(Mcp' = 1/Mcp = 1\} \quad (8)$$

Which is equivalent to: $$\Phi pp' = \frac{\sum c M_{cp} Mcp'}{\mathbf{max(kp,0kp'0)}} \quad (8')$$

The distance between a particular product p and the country c's existing productive capabilities (also referred to as capability gap) is calculated as the sum of proximities between p and all the products that country c is currently not exporting, normalized by the sum of proximities between product p and all other products. More formally:

$$\text{dcp}= \frac{\sum_{p'}(1-M_{cp})\Phi_{pp'}}{\sum_{p'}\Phi_{pp'}} \tag{9}$$

Having calculated the proximities and the distance, we can now technically derive the complexity outlook index (COI) as:

$$COI = \sum_{p'}(1-d_{cp'})\,(1-M_{cp'})PCI_p \tag{10}$$

Where PCI is the Product Complexity Index of product p' calculated as in Hidalgo & Hausmann (2009). The term (1−Mcp) ensures we only count the products that a country is not currently producing. A high COI reflects an abundance of nearby complex products that rely on similar capabilities or know-how as that present in current production. Conversely, a low COI reflects that a country has few products that are a short distance away, so will find it difficult to acquire new capabilities and increase their economic complexity (Hausmann, Hidalgo et al., 2014).

4.5. ECONOMIC COMPLEXITY AND GROWTH EMPIRICS

4.5.1. Economic Complexity and Structural Transformation

The economic complexity strand of research is closely related to the literature on structural transformation in that both emphasise changes in the composition of output as the key engine of growth. Balland et al. (2022) clarifies this point as follows:

> The economic complexity literature views economic development as a structural transformation process, whereby economic growth results from the transformation of a country's productive structure from one dominated by simple low-tech activities, typically unprocessed primary products, to one characterized by more technologically advanced manufacturing processes. By emphasizing changes in the composition of output, the complexity approach to growth and development is related to the literature on structural transformation (see Herrendorf et al., 2014 for a review). (Section 2.3).

Felipe et al. (2012) previously highlighted this point when they noted that the seminal contributions by Hidalgo et al. (2007) and Hidalgo and Hausmann (2009) revive the view pioneered by development economics founders (citing Lewis, 1954; Rostow, 1959; Kuznets, 1966); Kaldor, 1967; Chenery and Taylor, 1968). They point out that in the capabilities-based theory of economic complexity, "economic development is not only a process of continuously improving upon the production of the same set of goods, but more importantly, a process that requires acquiring more complex sets of capabilities to move towards new activities associated with higher levels of productivity" (p.37).

The contribution of economic complexity approach has been the use of complex network-based techniques to derive metrics that allow to analyse the productive structure of a country at a fine-grained level of disaggregation. Armed with these analytical tools, scholars have been able to investigate and provide interesting insights on the question of why some countries achieve sustained growth through structural transformation that allows them to develop while many others languish and seem not to be able to progress. We distinguish between this line of research papers that emphasise differences in the characteristics embodied in the products made by countries, such as the complexity of the products, and those that look at the location and dynamics of countries in the product space as explaining differences in their patterns of structural transformation and economic performance. This section summarily reviews the key findings.

The first line of research follows Hausmann, Rodrik and Hwang (2007) who argue that what countries produce and export matters in terms of their consequences for economic performance. Felipe et al. (2012) use Hidalgo and Hausmann's (2009) method of reflections and definitions of complexity to rank 5107 products and 124 countries. Their findings show that the most complex products are in machinery, chemicals, and metals, while the least complex products are raw materials and commodities, wood, textiles, and agricultural products. They also find that export shares of products of different complexity (in the country's total exports) vary with income per capita; that is, export shares of the most complex products increase with income, while the export shares of the less complex products decrease with income. Moreover, the sensitivity of export shares to income per capita increases the farther the complexity level of the product is from the average level of complexity.

In Felipe et al. (2014), the authors attempt to provide empirical evidence for the traps that many countries face to develop. To do so, they study the characteristics of their export baskets and classify 779 categories of exported products (physical goods, SITC-Rev.2 4-digit level) according to two dimensions: (1) sophistication (measured by the income content of the products exported); and (2) connectivity to other products. They identify 352 "good" products and 427 “bad” products (those that have low sophistication and/or are not well-connected to other products). Based on this, they categorise 154 countries into four groups according to these two characteristics. There are: (i) 34 countries whose export basket contains a significant share of good products (mostly sophisticated and well-connected); (ii) 28 countries whose export baskets contain a significant share of products that are in the middle of the sophistication and connectivity spectra. (iii) 17 countries that are in a “middle-low” product trap, and (iv) 75 countries that are in a difficult and precarious “low product” trap. These are countries whose export baskets contain a significant share of unsophisticated products that are poorly connected to other products. These countries find it hard to jump and diversify their economies into ever-increasing sophisticated products. Based on these findings, the authors argue that “what allows countries to become rich has to do with the type of economic activities they engage in (i.e., the type of goods they end up producing and exporting), and with the policies that they implement to promote and develop certain types of industries” (Felipe et al. 2014, p.47). These results are supported by other studies at the country level (e.g., China) which report evidence in support of Hausmann et al. (2007), in that regions specialising in more sophisticated goods subsequently grow faster (Jarreau & Poncet, 2012).

More recently, Fagerberg and Verspagen (2021) test the role of technology in structural change and economic catch-up, drawing on GDP and trade data for a large number of countries on different levels of development from the post-second world-war period. Their paper applies the classification (citing Lall, 2000), which assigns the 201 product classes in their database to one of six categories: commodities, resource-based manufactures, low-tech manufactures, medium-tech manufactures, high-tech manufactures, and other products. Their empirical analysis reveals a major divide in the global economy. On one hand, there is a group of modern, industrialised countries specialising in technology-based production. On the other hand, another group of countries specialises in commodities (which does not rely much on technology of any sort) and resource-based products (mostly of low-tech manufacturing nature), lagging both in terms of technology and income. Countries changing their specialisation patterns from commodities and resource-based manufactures to technology-based production categories enjoyed sustained growth, suggesting that structural transformation in the direction of technology-intensive exports (especially medium-tech and high-tech) is strongly related to catch-up-based growth.

The second line of research papers relies on the concept of relatedness, or the connectivity of products in the production space, following the framework developed by Hausmann and Klinger (2007) and Hidalgo et al. (2007). Hausmann and Klinger's (200)'s paper explores export performance in South Africa over the period 1960–2005 using the product space method and disaggregated export data from the World Trade Flows data from Feenstra et. al. (2005). Looking at South Africa's location in the Product Space from 1975 to 2000 at 5-year increments shows that the country 's production was located on the periphery of the product space, particularly in the earlier years. There has been some shift to goods located in a more central part of the product space, yet overall, the results show peripheral production with little structural transformation to new products in South Africa. This is in contrast with countries such as Malaysia, where there has been significant structural transformation, represented by the rapid movement of production from peripheral goods to the cluster of electronics-related goods. Therefore, the study found the slow structural transformation in South Africa to be a consequence of the peripheral nature of South Africa's productive capabilities.

Hidalgo (2009) explores the question of "How does the productive structure of countries' changes over time" by studying the changes in the relative complexity of products and in the structure of the product space with 42 years of trade data between 1963 and 2005. The results show that while the product space remains stable during this period, the dynamics of countries' productive structures are characterised by a few highly dynamic economies, such as Brazil, Indonesia, Türkiye, Malaysia, Thailand, Korea, Singapore, and China; these transformed their productive structures during these four decades. The visualisation of the structure of the product space shows that during the entire study period, some products, such as vehicles and machinery, populated the more densely connected part of the network. Some others, such as oil and its derivative products, agricultural products, and raw materials, remained consistently located in the less densely populated part of the product space, indicating that these remained peripheral products. The capabilities required in these sectors are hard to deploy for exploiting emerging opportunities in other sectors, thus constraining diversification, and sustained development.

Abdon and Felipe (2011) look at the economic development of Sub-Saharan Africa (SSA) in the context of structural transformation. They use Hidalgo et al.(2007) concept of product space to study the evolution of the region's productive structure and discuss the opportunities for growth and diversification. Their results show that the majority of SSA countries are trapped in the export of unsophisticated, highly standard products that are poorly connected in the product space, which makes the process of structural transformation in the region particularly difficult. Their findings also show that the products that are *nearby* that most countries in this region already export have the same characteristics. Therefore, shifting to these products will do little to improve SSA's growth prospects. Consequently, to jump-start and sustain growth, governments must implement policies and provide public input that will encourage the private sector to invest in new and more sophisticated activities.

Hidalgo (2012) explored the industrial opportunities of five south-east African countries (Kenya, Mozambique, Rwanda, Tanzania, and Zambia) using the Product Space to study their productive structures individually and collectively. Looking at the position of each of these countries in the product space suggests that the most natural avenue for future product diversification for these nations resides in the agricultural sector, since all of these nations appear to have productive structures that are pre-adapted to the production of many agricultural products that none of them are currently exporting. The results obtained by pulling together the productive structures of these five countries show that the products that become more accessible in the integrated economy are once again predominantly agricultural. The study concludes that while diversification into all sectors should remain an important long-term goal of the region, the path towards increased diversification soon may well lie in a more empowered and diversified agricultural sector.

Jankowska, Nagengast, and Perea (2012) examine why Latin American countries were not as successful as Asian countries in terms of escaping the middle-income trap. To this effect, they adopt the Product Space methodology to compare the structural transformation that took place in Asian and Latin American countries using a highly disaggregated (4-digit SITC) breakdown of trade data across industries. Their results suggest that the Asian countries that were successful in escaping the middle-income trap were the ones that engaged in a transformation of their productive structure from simple activities to manufacturing. Latin American countries fail to transform their productive structures, due to a lack of capabilities, in particular proper education, infrastructure and innovation policies, and access to finance.

Ferrarini and Scaramozzino's (2016)'s paper contributed to the debate on cross-country differences in economic performance by analysing the impact of production complexity and its adaptability on the level of output and on its rate of growth. They develop an endogenous growth model where increased complexity raises the rate of economic growth but has an ambiguous effect on the level of output. Their empirical analysis uses as a metric of complexity the average product density by country according to the Lafay product space, which they consider a measure of the adaptability of that country's production structure across sectors and can be interpreted as being related to the fungibility of its resource endowments and of its available technology. They evaluate the predictions of their theoretical model for a cross-section of 89 countries over the period 1990–2009. Their analysis provides empirical evidence that is consistent with the theoretical predictions and supports the view that production complexity is important to explain differences in economic performance.

Similarly, Ulimwengu et al.(2018) use the product-space approach and BACI dataset for the period 1995-2014 to analyse the role of agricultural value chains selected under the Agricultural Policy Support Project (PAPA) in Senegal's structural transformation process. Their simulation results suggest that exporting only non-processed agricultural products, even with revealed comparative advantage (RCA), is not enough to boost the country's structural transformation process. Exporting manufacturing products with RCA is by far the best option to fast-track structural transformation.

4.5.2. Economic Complexity and Growth Nexus

The seminal work of Hidalgo and Hausmann (2009) develops a new perspective for understanding the increasingly large gaps in income per capita across countries. Their view is that differences in the complexity of the productive capabilities available in countries are at the root of the divergence in income levels, as argued by both Adam Smith and the recent endogenous growth theories" (citing Grossman & Helpman, 1991; Romer, 1990). Using their metrics of the complexity of products and of countries, they were able to show that these metrics capture information about the complexity of the set of capabilities available in a country and that they are strongly correlated with income per capita and are predictive of future growth.

Following Hidalgo & Hausmann's strong empirical case that the level of development is indeed associated to the complexity of a country's economy, a growing empirical literature has examined the relationship between the productive capabilities available in a country and its long-term growth. Regardless of the economic complexity metrics used, there is a general agreement in the literature that the complex capabilities embedded in a country's productive structure are a harbinger of growth, a key determinant in cross-country differences in income levels and growth (e.g., Brummitt et al. 2020; Cristelli, Tacchella, Cader et al., 2017; Stojkoski et al. 2016; Tacchella et al., 2012).

In their paper – "What you Export Matters"- Hausmann, Hwang an Rodrik (2007) were the first to use a theoretical model supported with empirical evidence to demonstrate that the mixed of goods a country produces has important implications for economic growth. Empirically, they construct an index of the "income level of a country's exports," referred to as "EXPY"[17] , and find that this index is a strong and robust predictor of subsequent economic growth. This finding is robust when controlling for standard determinants of economic growth, both in cross-section and panel data models.

In Hausmann, Hidalgo et al. (2014), the authors analysed how the economic complexity measures compare with other approaches, such as "measures of governance and institutional quality", "measures of human capital", and "measures of competitiveness". Their regression analysis found that ECI can account for a significant percentage of the cross-country variation in income per capita and economic growth, and that ECI is a much stronger predictor of growth than other commonly used indicators that measure human capital, governance, and institutions. In particular, their findings show that: (i) ECI captures significantly more growth-relevant information than the six World Governance Indicators (WGI) either individually or combined; (ii) ECI contains information that is more directly related to a country's level of income and its growth than the standard variables used to measure human capital, such as years of schooling or cognitive ability; (iii) removing the ECI from the regression results in a much larger loss of explanatory power than removing the Global Competitiveness Index (GCI). The findings of this study are robust to controlling for numerous factors and have been replicated by multiple studies during the past decade using both international and subnational data.

In their paper, Poncet et al. (2013) study the effect of economic complexity on city-level GDP per capita growth in China, following the empirical growth model proposed by Barro (1991).

[17]Considered as the precursor of the economic complexity index (ECI), EXPY is a measure of the productivity level associated with a country's specialization patterns. It is calculated as the export weighted average of the PRODY for that country. PRODY is an income/productivity level calculated by taking a weighted average of the per-capita GDPs of the countries exporting a product, where the weights reflect the revealed comparative advantage of each country in that product (Hausmann, Rodrik, & Hwang, 2007).

They build a measure of economic complexity at the city level using the method of reflections of Hidalgo and Hausmann [2009] which reflects the diversity and ubiquity of capabilities present in the locality. Their estimates, based on a panel of 221 Chinese cities between 1997 and 2009, indicate that the more complex the city's productive structure, the faster its subsequent GDP per capita growth. The coefficient associated with the economic complexity index suggests that an increase of one standard deviation in economic complexity contributes 0.7 percentage points of yearly per capita economic growth, which is a clearly significant economic impact. These estimates are robust to the inclusion of control variables used to characterise the productive structure of an economy.

Stojkoski et al. (2016) investigate the impact of services on growth in the context of economic complexity. Their study adopts a nomenclature that classifies manufactured goods according to which products encompass both goods and services, which is in line with current trends in the economy where services are seen as products for direct consumption and investigates the influence of services on the country's productive structure. Their findings provide evidence that the complexity index for services is in general higher than that for goods, which is reflected in a general tendency to rank countries with a developed service sector higher than countries with an economy centred on the manufacturing of goods. More importantly, their results suggest that growth in service exports and their sophistication can provide an additional route for economic growth in both developing and developed countries. They argue that the converse may also hold—"[T]he countries (including those with diversified goods portfolio, i.e. saturated goods space) which are not able to accordingly populate the service space (i.e. diversify the service portfolio), may face diminishing growth prospects" (p.3). A similar result is found in Gao and Zhou (2017), who estimated the ECI of China's provinces between 1990 and 2015 using firm-level data, which allowed them to consider international as well as intra-national trade flows of goods and services. Their results show that diversified provinces tend to have industries with less ubiquity. Linking ECI to economic development and income inequality, they find that the predictive power of ECI is positive for the former but negative for the latter.

Chávez et al. (2017)'s paper uses information on the productive structure of each of Mexico's states to calculate a measure of economic complexity using the Method of Reflections proposed by Hausmann and Hidalgo (2009). Using employment data, the results suggest that the country's states differ markedly in terms of the activities they specialise in, and therefore also in terms of their economic complexity. There is also a clear regional pattern that shows that states in the north are more complex, those in the central region have an intermediate level of complexity, and those in the south have the lowest levels of complexity. Consistent with previous international studies, their results show that complexity is a key factor in explaining the economic disparities observed in the country. One standard deviation in economic complexity is associated with an increase in the rate of economic growth of Mexican states of about 0.4% per year, while controlling for a state's initial GDP per capita, oil production, and time-fixed effects. Comparable results are reported using data on Italian provinces, showing that one standard deviation in economic complexity was associated with 7–10% growth in GDP per capita in a 3-year interval (Coniglio, Lagravinese, & Vurchio, 2016). The same is true for Spain, where Balsalobre, Verduras, & Lanchas (2017) also found a positive correlation between economic complexity and growth using interregional trade data covering the 50 provinces (Nuts 3 following Eurostat terminology) and 17 regions (Nuts 2 following Eurostat terminology) during the period 1995-2015.

Domini (2022) uses data from the catalogues of five universal exhibitions held in Paris in 1855, 1867, 1878, 1889, and 1900 to compare the productive structures of participating countries, which were a major fraction of the world total trade. This allows him to overcome the lack of finely product-disaggregated comparative export data. He reconstructs the RCA and Economic Complexity Indices (ECI) for many countries in the second half of the 19th century based on this dataset. Overall, the results of his analysis extend to the second half of the 19th century and support the central claim of the economic complexity approach, i.e., that countries' capabilities, as measured by the complexity of their productive structures, are a major driver of long-run growth. These results, they point out, are fully consistent with those from the existing literature and with the constrained convergence literature, whereby successful catching-up by backward countries relies on the possession of adequate capabilities.

As revealed by the review of the existing empirical research papers on the relationship between economic complexity and growth, there is an overwhelming body of evidence suggesting that the capabilities embedded in the countries (regions/states)'s productive structures positively impact the long-term growth dynamics and explained the bulk of cross-country differences in income levels and growth rates. There is, however, more work to do with respect to two important aspects not yet clearly covered. First, there is a need to understand how changes in productive capabilities affect the within-country variations in economic growth - What is the role of productive capabilities accumulation in accounting for growth turning points (acceleration and deceleration) and for growth accelerations that are sustained or not? Second, there is less coverage of sub-Saharan countries in the empirical literature. Most studies either cover all developing countries as a group or focus on specific regions/states within a country. We need to understand how salient the productive capabilities are in driving the dynamics of structural transformation and growth in SSA. In the three next chapters in this study, we cover this research gap and empirically investigate these questions.

4.6. CONCLUSION AND SOME IMPLICATIONS FOR GROWTH RESEARCH

The complexity economics and evolutionary analysis reviewed in this chapter represent a significant departure from the mainstream neoclassical theory which has served as the dominant framework for growth research until recently. . While acknowledging the accumulation of factors such as physical capital, human capital, institutions, as important for growth to take place, this evolutionary theory of development boldly places technological learning at the core of the growth progress. Building on the concept of capabilities, economic complexity scholars view economic development as a process of learning how to produce (and export) more complex products. Departing from aggregative modelling – in which growth is explained as the consequence of the accumulation of aggregate factors, economic complexity scholars argue that a sustained growth trajectory must involve the introduction of new goods and not merely involve continual learning on a fixed set of goods. They emphasise that the development path of a country is determined by its capacity to accumulate the capabilities that are required to produce varied and more sophisticated goods.

Empirically, the economic complexity's finding - the complexity of a country's economy is a harbinger of growth, a key determinant in cross-country differences in growth - has important implications for the validity of empirical growth works that rely on the neoclassic-based growth regression framework. This framework completely ignores or neglects the role of complexity analysis in modelling the growth progress. However, as emphatically stressed by economic complexity scholars, measures economic complexity should be considered as potentially significant and robust explanatory variables in any correct econometric growth model (Stojkoski et al., 2016). Even more important, economic models of growth that overlook the role of complexity risk being severely mis specified and suffer from possible omitted variables bias (Sbardella et al., 2018).

Theoretically, the predictions of the economic complexity - regarding the emergence of a phenomenon referred to as “ a quiescence trap” or trap of development statis” rooted in the limited incentives faced by countries with low initial endowment of capabilities – open up new research venue to empirically test the presence of capability-based traps in resource rich countries where the rapid sustained growth failure has been attributed mainly to the presence of the resource curse. Under certain conditions, it is possible that what has been found to be evidence of resource curse is the manifestation of ‘ a quiescence trap.’

Therefore, given the theoretical and empirical implications of the economic complexity approach for growth research, the next chapter investigates the question of whether growth faltering in SSA is driven by the resource curse or rather a trap od development stasis or both.

CHAPER 5

FALTERING AFRICA'S GROWTH: RESOURCE CURSE OR QUIESCENCE TRAP

5.1. INTRODUCTION

The growth performance of sub-Saharan countries since the 1960s has been characterized by periods of turning points[18] (growth accelerations and decelerations) and growth spells (sustained growth) (Arbache, Go, & Page; 2008; Arizala et al., 2017; Gill & Karakulah, 2019; Ndulu et al., 2007; Raddatz, 2008). Following the methodology used in the empirical literature on growth turning points (citing Antoshin, Berg, & Souto. 2008; Berg, Ostry, & Zettelmeyer, 2012), Arizala and Co-authors find that, while growth up-breaks and down-breaks are common across the world, most growth turning points over 1950–2016 occurred in developing economies, with SSA experiencing about a quarter of them. While most down-breaks occurred during 1970–84, the region experienced less volatile growth and fewer down-breaks during 2000–2016 perod. With respect to growth spells, their findings show that they are as frequent as in other regions - 40 growth spells in SSA between 1950 and 2016 (27 percent of total spells identified over the sample period). However, growth spells in SSA are shorter than elsewhere, with median length of 6 years (6 years for resource-intensive countries, and 5 years for non-resource-intensive countries) compared to 10 years for other developing economies and 8 years for emerging market economies.

A growing theoretical and empirical literature reviewed in Chapters 2 and 3 has explored the factors at the root of sub-Saharan countries 'economic growth faltering. Of all the hypotheses investigated, the resource-curse has attracted the attention of scholars and generated a great debate over the last three decades since the seminal paper by Sachs and Warmer (1995). From the survey study conducted by Alssadek and Benhin (2023), nine out of ten papers published in leading journals between 2014- 22 period, and which focus specifically on Africa, find that

[18] In their growth turning points approach, Arizala et al. (2017) distinguishes between growth up-breaks—periods of higher growth than before the structural break, or growth accelerations—and down-breaks—periods of lower growth than before the structural break, or growth decelerations. They define "complete" growth spells as "periods of time that (1) begin with a growth up-break followed by a period of at least 2 percent average per capita income growth; and (2) end with a growth down-break followed by a period of less than 2 percent average per capita income growth"(p. 8).

resource-rich countries in this region are under the curse of natural resources; that is, their growth is hindered by the abundance of or dependence on natural resources (see **Appendi**x F: **Empirics of Resource Curse in Sub-Saharan Africa**). This suggest that an empirical study investigating the resource-curse hypothesis in Africa is more than likely to find evidence that the abundance of or dependence on natural wealth has adverse effects on growth or its determinants. Is sub-Saharan Africa different from other regions in developing countries where the evidence of resource curse is mixed with no consensus whether natural resource is a curse or a blessing? Is there something else that might be driving growth faltering in SSA but of which the evidence is mistaken for the resource curse?

Despite the heterogeneity in their results, existing studies on natural resource curse have in common that they adopt the empirical framework developed by Barro (1991), Mankiw, Romer and Weil (1992), which is based on the standard aggregate growth modelling and follows the regression-based approach. This empirical growth framework is underpinned by the neoclassical growth models which abstract from the complexity of the economy. On one hand, and as it has been recently pointed out by scholars from the economic complexity research, the standard aggregate modelling approach does not account for the complexity and interconnectedness of the economic system; it neglects the possible effects of uncountable heterogeneous interactions occurring at different scales of the economic system, of which growth is an emerging phenomenon (Cristelli, Tacchella, Cader et al, 2017; Cristelli et al., 2013; Hidalgo & Haussman, 2011). On the other hand, these scholars underscore that the regression-based approach is particularly appropriate only under the assumption that the economic system responds homogenously to a specific set of independent variables; this is rarely the case in economic systems which are heterogeneous (Cristelli et al, 2013).

While noting that the neglect of complexity and interconnectedness of the economic system in the mainstream economics is not an act of naiveté, but rather a natural consequence of the lack of tools available to describe them (Hidalgo & Hausmann, 2008), the novel strand of research on economic complexity has leveraged techniques from complex network theory and made it possible to quantify the variety of capabilities embedded in a country's productive structure in a manner that takes the sophistication of the products into account and captures differences in industrial structures at a fine-grained disaggregated data level (Hartman et al., 2017). In so doing, the economic complexity has revived the idea intuitively implied in endogenous economic growth models, which included the assumption that "the variety of inputs that go into the production of the goods produced by a country affects that country's overall productivity" (Hidalgo & Hausmann, 2009, p. , citing Grossman & Helpman, 19991; Aghion & Howitt, 1998).

This chapter focuses on the most recent growth boom in sub-Saharan countries that started in the mid-1990s. Few countries in the region, mostly resource-poor economies, continue to remain on the impressive growth spell they have been on since the early 2000s (see **Appendix B: Growth Forecast for Sub-Saharan Africa**), while growth has decelerated in the majority of countries with hard-landing in some cases. In this Chapter, we attempt to answer the question of why growth is faltering across sub-Saharan countries, focusing on the role of natural resources[19] and the country's productive capabilities, two structural factors that have not been investigated jointly in the resource curse literature or even separately in the empirical work on growth turning points in the context of sub-Saharan Africa.

To bridge the gap between the empirical literature on the curse of natural resources and the economic complexity theory of growth, we extend the standard growth regression model by including a new variable – the productive capabilities embodied in a country's economic system. We use this model as a unified framework to jointly evaluate the hypothesis of a resource curse and that of a quiescence trap, whereby economic diversification and growth are constrained by a lack of incentives to develop and accumulate new capabilities. While we focus squarely on SSA, we estimate the model separately for sub-Saharan countries and for a group of emerging and developing countries (hereafter, developing countries) comprising SSA. This strategy allows us to draw comparisons and understand whether the region's experience is different in terms of factors affecting long-term growth.

Overall, the results from the system generalised method of moments (System-GMM) indicate that sub-Saharan countries are stuck in a quiescence trap or trap of development stasis. First, natural resources have a positive but marginally significant effect on long-term growth in SSA during the growth acceleration period. This effect is positively significant in developing

[19] According to Izvorski et al.(2018), the share of natural capital in Africa's aggregate wealth is the second highest in the world after the countries that form the hydrocarbon-rich Gulf Cooperation Council (GCC). Even resource-poor SSA, with its relatively low level of natural capital per capita, has a share of natural capital in total wealth that is higher than resource-rich MICs outside Africa".

countries. Second, the complex capabilities embedded in a country's productive structure have a robust and significantly positive effect on growth in developing countries. In the subset of sub-Saharan countries, however, productive capabilities have a negative effect but are not significant on growth, suggesting that long-term growth in these countries is constrained by the slower accumulation of new capabilities. These results call for a shift from excessive focus on ensuring "sound macro fundamentals" to policies and programmes that support the accumulation of productive capabilities at the level of firms and countries.
The outline of the chapter is as follows: Section 2 presents the model specification, estimation method, and data sources. In Section 3 we present the estimation results for both SSA and developing countries. In Section 4 we discuss the results considering previous findings.

5.2.MATERIALS AND METHODS

5.2.1. Definition of key variables and sources of data

This subsection defines the variables used in the model and indicates the sources of data. We focus here on our two variables of interest: natural resources and the country's productive capabilities . We provide in **Appendix E (Definition of Key Variables and Sources of Data)** the definition and data sources for the full set of variables used in the model.

Our first variable of interest is natural resources. Existing empirical works on resource curses have used different proxies for natural resource variables, depending on whether they focus on resource dependence or resource abundance. Commonly used resource dependence measures include primary resource exports as share of GDP, primary commodity exports as a share in total merchandise exports, natural resources as a share of primary exports, natural resource rents as share of GDP, share of natural capital in national wealth, share of mineral exports in total exports, etc. For resource abundance, commonly used measures are total natural capital per capita, subsoil assets per capita, oil production/oil revenues / oil reserve per capita, per capita natural resource rents, etc. These proxies often lead to conflicting evidence on the very existence of the resource curse and its transmission mechanisms (see Sachs & Warmer, 1995 vs Brunnschweiler & Bulte, 2008). For different measures of natural resources used in empirical studies and a summary of their findings, we refer interested readers to Alssadek & Benhin (2023) and Baddeb et al. (2017).

In this paper, we focus on natural resource dependence. This choice follows Badeeb et al.(2017, p. 132) who conducted a survey of empirical literature on resource curses and argue that the existence of resource curses “does not refer to a country's possession of natural resources, but rather its overwhelming dependence on one or two of them (citing Karl, 2005). Badeeb and co-authors cite the work of Gylfason & Zoega (2006) who formalise this distinction by modelling the interplay between natural resource dependence/abundance and economic growth in the Cobb-Douglas function ($Y = AL^aN^bK^{1-a-b}$) , where output Y is produced by labour L, natural resources N, and capital K, with A representing overall technological efficiency. Rewriting the production function in per capita terms ($y = An^bk^{1-a-b}$), Gylfason & Zoega find that the greater the role of natural resources in the generation of national output (i.e. the greater is b), the lower the output growth; whereas the greater the n, the greater the output growth.

Having chosen to focus on resource dependence rather than abundance, we subsequently choose total rents from natural resources (share of GDP) as a proxy variable to measure it. According to the World Bank Glossary, total natural resources rents (TNRR) are the sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents, and forest rents. They are calculated as the difference between the price of a commodity and the average cost of producing it. The total rents from natural resources (share of GDP) are widely used in recent empirical work focusing on dependence (see Shahbaz et al.2019 and reviews by Alssadek & Benhin, 2023; Badeeb et al. 2017). The popular use of this indicator is supported by the arguments in emerging theoretical and empirical literature, which show that the direction in which natural resource dependence affects growth, whether directly or via its long-term determinants, is contingent on the economics and politics of managing revenues from natural resources. Countries that are successful in managing the multistage challenges of transforming natural resources into physical and human capital (e.g. Botswana, Malaysia, Sweden) are found to avoid the curse, while those that fail suffer from it (Venables, 2016).

The second variable of interest in our models is the productive capabilities embedded in the productive structures. Measuring capabilities has been a challenging endeavour, due to a lack of coarse-grained data at activity or product levels. More recently, economic complexity scholars have combined methods from complex network science and machine learning techniques to develop metrics that quantify a country’s productive structure (Hidalgo & Hausmann, 2009; Tacchella et al., 2012; Cristelli et al. 2013). From easy-to-find and publicly accessible data, these metrics extract information about the diversity and sophistication of a country's export basket to quantify the productive knowledge owned by each country – which embeds capabilities, finance, technology, human capital, and resources (Sciarra et al., 2018). The key idea underpinning economic complexity methods is to consider the international trade of countries as a proxy of their internal production system (Saltarell et al. 2020).

The commonly used methodologies to measure economic complexity produce two different metrics- namely the economic complexity index (ECI) and the economic fitness (EF). The ECI is derived from the Method of Reflections (MR), and it is a measure of how diversified and sophisticated is the productive knowledge embedded in a country economic system. Countries that possess a great diversity of productive know-how, particularly complex specialized know-how, can produce a great diversity of sophisticated products (Hausman et al., 2014). Details on the procedures for the computation of ECI were provided in Chapter 4, Section 4.4.1.

The economic fitness (EF) of a country is obtained from using a non-linear algorithm that considers the ubiquity of products and their complexity. It is a synthetic measure of the degree of country's competitiveness in terms of the capabilities embedded in their economic system for the production and export of diversified and complex products/services. "Countries with the highest levels of EF have capabilities to produce a diverse portfolio of products, ability to upgrade into ever-increasing complex goods, tend to have more predictable long-term growth, and to attain good competitive position relative to other countries" (World Bank Glossary). Details on how the economic fitness is computed are provided in the next subsection 5.2.2.

Related to economic complexity, is the metric of complexity outlook index (COI), defined in the product space - a visualisation that depicts the connectedness between products based on the similarities of the know-how or capabilities required to produce and trade them in tandem on the global market (Hidalgo & Hausman, 2007). COI is a measure of how many complex products are near a country's current set of productive capabilities. It captures the ease of diversification for a country, where a high COI reflects an abundance of nearby complex products that rely on similar capabilities or know-how as those present in current production. A country with a high COI has paths to diversification into compel sectors: products associated with high added-value and productivity, whereas countries with low COI are positioned in the periphery of the product space network and have few paths to diversification into complex products. These countries will find it hard to achieve productivity-enhancing structural transformation (Hausmann et al., 2014).

5.2.2. Metrics: Economic Fitness of Countries and Complexity of Products

Metrics of economic complexity aim at uncovering the productive knowledge or capabilities embedded in countries ‘economic systems grounded on their export baskets (Hidalgo & Hausmann, 2009). The key idea behind this is that each country’s economic system is characterised by its endowments, or capabilities, which represent its social, cultural, and technological structure (Patelli et al. 2022: citing Dosi et al., 2000). These capabilities are expressed in what a country produces and exports. If this is the case, then economic complexity scholars argue that the productive basket of a country is able to discount and reflect (almost) all the information encoded in the intangible assets, usually hardly modellable, just as we can infer properties such as diversity and exclusivity of the Lego pieces inside the child’s bucket by looking only at the models that a group of children, each with a different bucket of Lego, can make (Hidalgo & Hausmann, 2009). Adding another analogy, Cristelli, Tacchella, & Pietronero (2015) point out that, from a conceptual point of view, the approach to measuring economic complexity resembles the so-called efficiency property of financial markets, where, at least in principle, prices should reflect all the available sources of information.

In chapter 4 we represented schematically the economic complexity framework in terms tripartite country-capability-product network in which capabilities are the intermediate layer between countries and products (see Fig. 4.1). We note that, due to the non-observability of capabilities, one can only access the ‘‘contraction’’ of this tripartite network into the bipartite country-product network. In this network, exports of countries can be informative about capabilities - that is an observation of a country’s export of a given product can tell us about the presence of specific capabilities. Borrowing from graph theory, the country-product bipartite network derived in figure 4.2 can be mathematically represented using a bipartite graph G is described by a binary matrix M defined as:

$$M_{i,j} = \begin{cases} 1, & if\ an\ edge\ or\ link\ exists\ between \text{ ai and bj} \\ 0, & otherwise \end{cases} \tag{5.1}$$

In terms of bipartite trade network, a binary country-product matrix M can be defined with elements Mcp, indexed by country c (in rows) and product p (in columns) (Hausmann et al., 2009).

While the economic complexity approach relies on export data to build the bipartite trade network, various metrics of economic complexity are not directly computed from the raw export volume. There are two reasons: i) the export volumes depend on both the size of the sector and the country, and ii) they do not provide a uniform assessment of the competitiveness of the given country in exporting a product" (Patelli et al., 2022, p.). To deal with these issues, the Revealed Comparative Advantage (RCA), introduced by Balassa (1965) is commonly used. RCA is used as a filter to make the raw export volumes binary quantities because the interest is in qualitative differences (i.e. what), rather than quantitative (i.e. volumes) differences in the export baskets of countries: "which kinds of products are exported competitively, not in which volumes." Moreover, RCA is not only a robust indicator of countries' competitiveness in the global market but also a predictive tool for economic growth (Morrison et al., 2017; Tacchella, Mazzilli, & Pietronero, 2018). In the formula, the RCA of country c in product p a is computed as:

$$RCA_{cp} = \frac{X_{cp}}{\sum_p X_{cp}} \Big/ \frac{\sum_c X_{cp}}{\sum_{cp} X_{cp}}, \tag{5.2}$$

where X_{cp} is country c's exports of product p.

We can then define the binary matrix M whose element Mcp is equal to 1 if RCAc, p ≥ 1), and it is equal to 0 otherwise.

$$M_{cp} = \begin{cases} 1 & if \text{ RCA}_{cp} \geq 1 \\ 0 & if \ RCA_{cp} < 1. \end{cases} \tag{5.3}$$

The binary matrix's entries Mcp are 1 if the country c has a revealed comparative advantage in product p larger or equal to 1, and 0 otherwise. Note that the binary C × P matrix M defines the topology of the bipartite network, whose nodes are countries and exported products (C and P are the number of countries and the number of products, respectively).

In chapter 4 we visualised the bipartite network matrix M (see Fig. 3) and showed that it reveals a clear statistical feature of nestedness, a key property of complex ecosystems that are both adaptive and evolutionary and where actors compete for finite resources (Cristelli et al., 2017, citing Dominguer-Garcia et al, 2015).

The nested structure of the binary matrix Mcp sets strong constraints on the mathematical specifications of the algorithm, which intends to measure the economic complexity of countries and the products they produce and export. Whether these constraints are considered or not differentiates the commonly used methodologies in economic complexity research, namely the Method of Reflections (MR) (Hidalgo & Hausmann, 2009) and the Economic Fitness and Complexity algorithm (Tacchella et al. 2012, Cristelli et al., 2013). As rightly pointed out by Sciarra et al. (2021), these two methods share a common root, but they radically differ in the conceptual approach to the problem and, therefore, in the obtained outcomes.

In this paper we apply the Economic Fitness and Complexity (EFC) algorithm for two reasons. First, the EFC algorithm has been shown to be optimal for nested structures of the country-product network (Mariani et al.2015). As stressed by Pietronero et al. (2019), the Fitness and Complexity algorithm “is different from the Google Page Rank and it suggests that for each Big Data problem one should identify the appropriate algorithm which better extracts the optimal information” (p.4). Second, Several papers have countered on the assumption of a linear relation between the products’ and countries’ complexities and shown that the economic complexity index (ECI) does not take into any consideration the important role of diversification, even though this was proposed as one of the motivations for the introduction of ECI (see e.g., Pietronero et al., 2019; Gabrielli et al., 2017; Cristelli et al., 2013; Tacchella, et al., 2012). This scholarship shows that the Method of Reflection approach uses a linear algorithm that derives a country’s economic complexity as the average of the complexities of the products in its export basket, and a product’s complexity as the average of the complexities of the countries exporting it. Thus, as an effect of taking the averages, the obtained complexity measures turn out to lose information about countries’ diversification and products’ ubiquity. Therefore, it is demonstrated, ECI leads to completely unrealistic results in terms of countries ranking, as for instance, the derivation that Qatar or Saudi Arabia are industrially more competitive than China (Pietronero et al., 2019).

The EFC algorithm aims at assessing the competitiveness, or Fitness, of a country and the sophistication or Complexity of products it produces and exports, leveraging on the nested structure of the binary matrix Mcp. Tacchella et al. (2012) firstly proposed an iterative algorithm which consists in self-consistent non-linear coupled equations for the Fitness of countries - the competitiveness dimension for countries- and the Complexity of products. The mathematical specification of this iterative algorithm is given in Eq.1:

$$Iteration\ (n) = \begin{cases} \tilde{F}_c^{(n)} = \sum_p M_{cp} Q_p^{(n-1)} & F_c^{(n)} = \frac{\tilde{F}_p^{(n)}}{\langle \tilde{F}_c^{(n)} \rangle} \\ \tilde{Q}_p^{(n-1)} = \frac{1}{\sum_c \frac{M_{cp}}{F_c^{(n-2)}}} & Q_p^{(n-1)} = \frac{\tilde{Q}_p^{(n-1)}}{\langle \tilde{Q}_p^{(n-1)} \rangle} \end{cases} \tag{5.4}$$

With initial condition: $\sum Q_p^{(0)} = 1 \; \forall \; p.$ (5.5)

In Eq. (5.4), Fc(n) and Qp(n) are respectively the fitness of a country and the complexity of a product at the nth iteration of the algorithm, and Mcp are the entries of the binary matrix M. C and P are, respectively, the number of exporting countries and exported products. The symbol <·> denotes the arithmetic mean with respect to the possible values assumed over all fitness values (in the case of F(n)), and over all complexity values (in the case of Qp). n) overall complexity values. The fixed point of this map operatively defines the measure for country competitiveness (i.e., the Fitness dimension) and the product complexity. The iteration of the coupled equations in (1) \leads to a fixed point, which has been proven to be stable and non-dependent on initial conditions. The convergence properties of Eq.2 are not trivial and have been extensively studied by Pugliese et al. [43].

As in the standard metric of economic complexity, the Fitness Fc is naturally proportional to the sum of the products exported weighted by their complexity Qp. A higher economic fitness score for a country is indicative of higher level of complex productive capabilities and global competitiveness. For Qp, the complexity of a product is inversely proportional to the number of countries which export it. The higher the complexity index for a product, the more complex it is in terms of capabilities required to produce and export it. Notably, if a country has a high fitness this should reduce the weight in bounding the complexity of a product, and the countries with low fitness should strongly contribute to the bound on Qp. This result is dictated by the nested structure of the bipartite trade networks (Tacchella, Cristelli et al., 2012).

In Pietronero et al. (2019), the authors point out that the equation (1) of the fitness algorithm is precisely the complexity-weighted diversification introduced in Brummitt et al.(2020) and set a sound framework for economic complexity that can be subjected to all validity and consistency tests. For Cristelli, Tacchella, & Pietronero (2015), fitness is a new economic dimension that quantitatively addresses the complexity and diversity of countries’ productive sets. It represents a synthetic measure of the whole network of interaction among capabilities and consequently allows for quantifying the hidden growth potential of countries by comparison with monetary figures such as GDP per capita.

5.2.3. **Model Specification and estimation method**.

5.2.3.1. Specification of the model

The natural resource curse empirics widely adopt the standard empirical growth framework proposed by Barro (1991) and Mankiw et al. (1992) (see survey studies by Alssadek & Benhin (2023), Badeeb et al. (2017)). For comparability, this study follows the same regression framework and uses the linear dynamic panel model described in Equation (1) as follows:

$$grGDPpc_t = \alpha + \beta logGDPpc_{i,\,t-1} + \theta NRES_{i,t} + \phi PRODCAP_{i,t-1} + Z'_{i,t}\delta_k + \mu_{\mathbf{i}} + \lambda_t + \varepsilon_{\mathbf{i,t}} \tag{5.6}$$

where $grGDPpc_t$ = $logGDPpc_{it}$ - $logGDPpc_{it-1}$ is the growth rate of GDP(PPP) per capita between period t and period t-1; NATRES represents the natural resources, measured by total natural resource rents (as % of GDP). PRODCAP represents the country's productive capabilities, measured alternatively by the Economic Complexity Index (ECI), the Economic Fitness Index (FITNESS) and the Complexity Outlook Index (COI). Z represents a set of additional control variables: μ is the individual fixed effect for country i, λ is the time-specific effect for each sub-period, and ε is the time-varying error term. i=1,2…. N indexes observational units (countries) and *t* indexes period, t = 1, 2,T; k denotes other control variables; α is the constant; and β, θ, ϕand δ_k are the coefficients to be estimated.

In addition to natural resources and country's productive capabilities as the two variables of interest, the set of other conditioning variables Z includes several factors that have been identified in the empirical literature as long-term growth determinants. These include investment rate, human capital, life expectancy at birth, financial development, institutional quality, employment rate, and trade openness.

A panel data approach is adopted in this paper as it is often advocated for growth empirics, especially for econometric analysis of the convergence in growth rates across different countries (Islam, 1995; Caselli et al. 1996). By blending inter-country differences and intra-country dynamics, the panel data approach has several advantages over cross-sectional or time-series data (Wooldridge, 2009; Caselli et al. 1996, Islam, 1995). Our choice of fixed effects model as the most appropriate is natural given the macro dataset used in this paper. As argued in Judson & Owen (1996), with macroeconomic datasets, if the individual effect represents omitted variables, it is highly likely that these country-specific characteristics are correlated with the other regressors. Moreover, when the panel contains most of the countries of interest, as is the case in this paper, it is unlikely to be a random sample from a much larger universe of countries.

5.2.3.2. Estimation methods

In this subsection, we rigorously discuss issues surrounding the growth regression model in a dynamic panel setting. This discussion will set the basis for the choice of the estimation method employed in this paper. But before we do this, let us say something about the characteristics of our dataset. The variables included in the model are measured by annual observations spanning from 1995 to 2018 for 124 emerging and developing countries, of which 42 are in SSA. Previous empirical works on growth regression suggest that yearly time spans are too short and inappropriate for studying growth convergence (Barro, 2003; Bond et al. 2001; Beck, 2000; Caselli et al. 1996). To avoid modelling cyclical business dynamics, these studies recommend using spans of at least five-year time intervals. We follow this empirical practice by taking averages for every 5 years, which reduces our dataset to four data points (time) from 1998-2018. Thus, the dataset used in the model estimation is a panel with many countries (N) and a small-time dimension (T).

Next, for simplicity of discussion, the linear dynamic panel model specified in Eq. (1) can be rewritten in a standard form as follows:

$$\ln (Y_{it}) – \ln(Y_{it-1}) = \beta \ln(Y_{it-1}) + X_t\psi + \mu_i + \lambda_i + \varepsilon_i. \quad (5.7)$$

where Y_{it} is per capita GDP in country i in period t, X_{it} is a row vector of determinants of economic growth, and ψ is a vector of coefficients to be estimated. We can rewrite Eq. (5.7) as:

$$\ln(Yi_t), = \rho \ln(Yi_{t-1}) + X_t\psi + \mu_i + v_{it} \quad (5.8)$$

where $\rho = \beta - 1$, and $v_{it} = \lambda_i + \varepsilon_{it}$

Equqtion (5.8) can be estimated to identify the determinants of GDP per capita.

In the context of empirical growth studies, several papers have demonstrated that the usual Ordinary Least Square (OLS) method and its variants (POLS, LSDV, IV, GLS, etc) have serious shortcomings that render them inappropriate for the estimation of parameters (Caselli et al.1996; Bond et al., 2001). These shortcomings have to do with challenges arising from individual fixed effects, the endogeneity of regressors, and the dynamic panel bias.

The first issue is whether the unobserved heterogeneity captured in the individual-specific effects can be assumed to be independent, or at least uncorrelated, with the observed explanatory variables included in the vector X (exogeneity assumption). In the case of a random effects model where the country-specific effects are assumed to be uncorrelated with the exogenous variables included in the model, estimators relying on such assumptions as GLS may be appropriate. For a dynamic panel model with fixed effects, the least squares with dummy variables (LSDV) estimator are no longer appropriate, due to the dynamic character of the model. The inclusion of a lagged dependent variable among the regressors on the right-hand side of equation (3) renders the random-effect assumption invalid while making LSDV an inconsistent estimator when $N \to \infty$ (Islam, 1995; Castelli et al. 1996). The difference estimator (even differences of lengths greater than one period) is also inconsistent, Further, Castelli et al. (1996) show that even the $\prod$-matrix approach proposed in Chamberlain (1984) - adopted in the then existing empirical growth studies (citing Knight, Loayza, & ViUaneuva, 1993; Loayza, 1994; Islam, 1995) to address the issue of correlated individual effects is inconsistent.

The second shortcoming has to do with the issue of endogeneity. The right-hand-side variables in growth regressions are typically endogenous and measured with error, leading some researchers to wonder whether the very notion of exogenous variables is at all useful in a growth regression framework (Caselli et al. 1996). These scholars persuasively argue and provide empirical evidence that, in most specifications of the growth model, at least a subset of the explanatory variables is conceptually endogenous. They show that economic growth affects the recurrent right-side variables in most growth regression studies, pointing to several variables that are determined simultaneously with the rate of growth and are often included as determinants of growth. In addition to the lagged GDP per capita to account for growth convergence, these right-side variables include the rate of investment in physical and human capital, trade openness, the rate of population growth, institutions, etc.

When the model specification includes as one of the regressors a lagged dependent variable, the usual approach to estimating a fixed-effects model generates a biassed estimate of the coefficients. Nickell (1981) derives an expression for the bias when there are no exogenous regressors, showing that the bias approaches zero as T approaches infinity. Based on this and their overview of the empirical literature on the determinants of growth, Caselli and Co-authors argue that "*almost all existing cross-country regressions, either based on cross-section, or panel-data techniques, have been estimated inconsistently" (p.369).*

To simultaneously address the issues of endogeneity and correlated individual effects in the estimation of growth regressions when a dynamic panel-data model is specified, Caselli et al.(1996) propose the use of the Generalised Methods of Moments (GMM) estimators initiated by Holtz-Eakin, Newey, & Rosen (1988) and further developed by Arellano and Bond (1991). The basic idea of the GMM method is to write the regression equation as a dynamic panel data model, take first-differences to remove unobserved time-invariant country-specific effects, and then instrument the right-hand-side variables in the first-differenced equations using levels of the series lagged by two periods or more, under the assumption that the time-varying disturbances in the original levels equations are not serially correlated. Formally, the first step in the estimation procedure is to eliminate the time-invariant and individual effects via a first-difference transformation:

$$y_{it} - y_{t-1} = \rho\,(y_{it-1} - y_{it-2}) + (X_{t-1} - X_{t-2})\psi\ + (\varepsilon_{it} + \varepsilon_{it-1}) \qquad (5.9)$$

However, even though individual effects are removed, Eq. (4) cannot be directly estimated by the application of OLS techniques. There remains a correlation between the lagged dependent variables and the error term. In the context of growth regression, there is still a problem of endogeneity of the "flow" variables in Xit and Xit-2s. Both issues render the "within estimator" inconsistent. The solution proposed by applying the GMM estimator consists of optimally exploiting all the linear-moment restrictions implied by a dynamic panel-data model by using all the past values of the explanatory variables as instruments. Following Bond et al. (1991), Caselli et al.(1996) show that this estimator, referred to as first-difference GMM, is consistent and efficient under certain identifying assumptions. In particular, the consistency property hinges on the identifying assumption that the lagged values of the dependent and the other explanatory variables are valid instruments in the growth regression.

In Bond et al. (2001), the authors show that while first-differenced GMM has important advantages over simple cross-section regressions and other estimation methods for dynamic panel data models, there may be a serious drawback with this method in the context of growth regression. They point out that in growth regressions – typically those using panel data with a small number of time periods to avoid modelling cyclical dynamics, and where GDP per capita is a highly persistent time series, lagged levels of the variables are only weak instruments for subsequent first-differences. Under these conditions, they argued, using a first-differenced GMM estimator can result in a large, finite sample bias. On this basis, these authors revisit the work of Caselli et al. (1996) and point out that earlier results in the empirical growth literature may be seriously biassed due to the weakness of instruments.

Although it is possible to strengthen first-differenced GMM using external instruments, for empirical growth studies, Bond et al. (2001) strongly recommend the use of system GMM estimator suggested by Arellano & Bover (1995) and Blundell & Bond (1998). These authors make additional assumption -requiring that the first differences Δyit be not correlated with ηi –that yields further linear moment conditions and permit lagged first-differences to be used as instruments in the level's equations. Thus, the System-GMM simultaneously estimate a system of equations in both first differences and levels. Suitably lagged levels are used as instruments in first-differenced equations, while suitably lagged first-differences are used as instruments in the additional equations in levels20. For AR (1) model as well as for a model with a lagged dependent variable and additional right-hand-side variables, GMM estimator results in remarkable reductions in finite sample bias and gains in efficiency from exploiting these additional moment conditions (Rodman, 2009; Bond et al., 2001; Blundell et al. 2000).

The consistency of the chosen GMM estimator depends both on the validity of the assumption that the error term does not exhibit serial correlation and on the validity of the instruments. The assumption and the validity of the instruments can be empirically evaluated using post-estimation tests proposed by Arellano and Bond (1991). The assumption of no serial correlation is examined using the Arellano-Bond test to check whether the idiosyncratic error term is serially correlated. Under the null hypothesis of no second-order serial correlation, this test has a standard-normal distribution. Thus, ideally, we should reject the null hypothesis of no first-order serial correlation in first differences (AR (1), but the test should not reject the null hypothesis of no higher-order serial correlation in first differences (AR(2), AR(3). The validity of instruments is evaluated using the standard Sargan/Hansen test of over-identifying

[20] For details on the derivation of the system GMM estimators, see Blundell & Bond (1998). Their paper also reporst evidence from Monte Carlo simulations that compare the finite sample performance of the first-differenced and system GMM estimators.

restrictions. The null hypothesis is that all over-identifying restrictions are valid, while the alternative hypothesis is that at least one of them is invalid. Under the null hypothesis of the validity of the instruments, the Sargan/Hansen test has a Ch2 distribution with (*J-K*) degrees of freedom, where *J* is the number of instruments and *K is* the number of regressors. Further, since the System GMM makes additional assumptions that yield further linear moment conditions and permit lagged first-differences to be used as instruments in the level equations, the validity of these additional instruments can be evaluated empirically using Difference-in-Hansen tests of the exogeneity of instrument subsets.

Our growth regression model, as specified in Eq.3, fits well with the conditions listed by Rodman (2009) for the use of GMM estimators. (i) "small T (panel spanning from 1998-2018 but averaged over 5-year periods to avoid business cyclical dynamics) and large N panels (large number of countries); (ii) linear functional relationship; (iii) independent variables that are not strictly exogenous; (iii) one left-hand-side variable that is dynamic, depending on its own past realisations; (iv) independent variables that are not strictly exogenous; (v) fixed individual effects; and (vi) heteroskedasticity and autocorrelation within individuals but not across them. Therefore, following the contributions of Caselli et al. (1996) and Bond et al.(2001) in the context of empirical growth work, we adopt system GMM estimator.

5.3.EMPIRICAL RESULTS

This section presents the estimation results for the regression models which we specified in Section 2. The resource curse hypothesis has been empirically evaluated using either the model of GDP per capita determinants or GDP per capita growth determinants (see empirical studies surveyed by Alssadek & Benhin, 2023). Likewise, given its predictions for both the income levels and the future growth of income, empirical studies reviewed in Chapter ', Section 5 have tested this prediction using either level of GDP per capita or its growth ad the dependent variable. Consequently, we estimated both models a present the results separately.

The original dataset includes 124 emerging and developing countries (here and thereafter "developing countries") of which 42 are from SSA. However, due to the unavailability of complete data series for some countries over the period covered by the study, the model was estimated for 98 countries, of which 35 are sub-Saharan countries. We first estimate the model for developing countries as a whole and then for SSA as a subgroup. To comparison with previous empirical works on resource curse, four different regression models were estimated for each group of countries. The first regression estimates the baseline model, which omits country's productive capabilities as a potential growth determinant. The three other regressions include the country's productive capabilities using alternative metrics: – Economic Fitness (EF) score, the Economic Complexity Index (ECI), and the Complexity Outlook Index (COI)

5.3.1. Descriptive statistics

Before presenting the regression results, we summarise key statistics on the variables included in the models in Table 5.1. These statistics reveal some distinctive features of SSA countries as a subgroup of developing countries. SSA is strikingly lacking in two important aspects, namely the complexity of the country's productive structure and financial development.

First, considering alternative measures of economic complexity, the mean values of the log economic fitness and economic complexity index for SSA stand at -1.106 (EF score = 0.331) and -.7463 against -0.713 (EF score = 0.490) and -.3362 for the developing countries. Moreover, the outlook complexity index for SSA has a mean value of -.7463, less than half that of the developing countries to which it belongs. Compared based on these statistics, it is fair to say that SSA is home to countries that are, on average, characterised by structures of production that embed less productive knowledge and capabilities.

The productive structures of these countries position them on the periphery of the network of products and services traded in the world, with only a few paths into diversification and upgrading in the production of complex products and services. Second, SSA is lagging in terms of financial development. The mean value for this variable is estimated at .1366 against 0.2181 for developing countries as a group. This relative low level of financial intermediary development points to the daunting challenges that SSA countries are facing in allocating society's savings and promoting productive investments, as both financial markets and financial institutions are less developed.

Table 5. 1. Summary descriptive statistics

Variables	Emerging economies and developing countries					Sub-Saharan African countries				
	bs	ean	t.dev	in	ax	bs	ean	t,dev	in	ax
GDPpc, log	76	.78	.05	.44	1.57	64	.92	8726	.44	0.21
Total Natural resource rents	496	.703	1.51	.00	1.58	67	1.77	.90	01	8.32
Economic fitness, log	94	0.713	.013	5.116	.383	68	1.106	7612	3.817	2231
Economic complexity index	96	.3362	7117	3.630	.846	68	.7463	4384	2.200	4974
Complexity outlook index	96	.0889	.007	1.775	.150	68	.4754	8933	1.752	.95
Investment rate	72	.2086	0815	0350	5116	64	.1937	0922	035	5112
Human capital index	12	,209	5913	.071	.490	44	1.744	4295	.071	.860
Life expectancy (inverse)	96	.0153	0022	0121	0231	68	.0176	0021	0132	0231
Employment rate	76	3813	0820	1620	7296	64	3670	0676	2332	5509
Financial development index	80	2181	1420	0012	7158	64	.1366	1063	0012	5667
Trade openness	72	4309	2774	0514	.611	64	.3785	2725	0514	.405
Political stability	91	.4393	8497	2.81	,204	68	.5392	8897	2.459	.04
Control of corrupton	92	.5070	6073	1.62	.456	68	.6095	6275	1.564	998
Rule of law	92	.5073	6335	2.152	.246	68	.6278	6355	1.78	9613

In respect to other important characteristics, SSA is more dependent on natural resources than the group of emerging and developing countries, with a mean value of 11.77 against 9.7 for the share of total natural resource rents in GDP. This is in line with previous works (e.g. Izvorski et al., 2018) that show that SSA is more dependent on natural resources than any other region in the world. On institutional quality and governance, there are also noticeable differences, with the SSA doing less well than the group of emerging economies and developing countries in terms of political stability, control of corruption, and rule of law. The same can be said for human capital and life expectancy.

5.3.2. Regression Results

5.3.2.1. Evaluating the resource curse and quiescence trap. GDP per capita determinants

Table 5.2 shows the estimation results for developing countries (1a) – (1d) and for SSA. In the first column of each country grouping [(1a) and 1(b)] are the estimates for the baseline model, which does not include the country's productive structure as an explanatory variable for GDP per capital. In the other columns are the regression results when alternative proxy variables for the country's productive capabilities are included in the model.

Overall, the results show strong heterogeneous effects in growth dynamics between SSA countries and the group of emerging and developing countries. Natural resources and a country's productive capabilities are both robust and significant positive drivers of GDP per capita in emerging and developing countries during the growth acceleration period under study. However, in the sub- set of SSA countries, natural resources dependence and productive capabilities are not significant determinants of GDP per capita.

First, in the regressions for sub- Saharan Africa as a stand-alone subgroup, both natural resources and productive capabilities of countries had no statistically significant effect on the dynamics of GDP per capita. In both sub-Saharan Africa and developing countries, there is no evidence of a resource curse. These results are robust to alterations in the conditioning information. The regressions for developing countries (1a – 1d) show that the coefficients associated with total natural resource are positive and statistically significant at 1% level. In other words, higher levels of natural resource rents are positively associated with higher GDP per capita. However, once SSA is isolated as a distinct group, the results change substantially. As shown in columns (2a – 2d), natural resources have marginally positive effect on GDP per capita in the baseline regression; Once productive capabilities are included, natural resource rents coefficients are positive but statistically insignificant.

Table 5. 2. Regression results: determinants of GDP per capita

	System Generalized Method of Moments (Sys-GMM) Dependent variable: log GDPpc (5-year averages)							
	Emerging economies and developing countries				Sub-Saharan African countries			
Variables	(1a)	(1b)	(1c)	(1d)	(2a)	(2b)	(2c)	(2d)
$GDPpc_{t-1,}$ log	.5217*** (.1383)	.7828*** (.2076)	.5982*** (.1874)	.6376*** (.1576)	.9410*** (.0882)	.9623*** (.0854)	.9553*** (.0889)	.9766* (.0803)
TNR Rents	.0087*** (.0034)	.0125*** (.0026)	.0147*** (.0044)	.0131*** (.0028)	.0039* (.0021)	.0010 (.0029)	.0023 (.0026)	.0023 (.0031)
Economic fitness, log		.1775** (.0853)				-.0665 (.0434)		
ECI			.4076** (.2085)				-.0951 (.0698)	
COI				.1558* (.0854)				-.0337 (.0447)
Investment rate	.2629 (.1903)	.4114*** (.1521)	.2860 (.2401)	.4394** (.1881)	.3510* (.2085)	.2733 (.2039)	.2944 (.2045)	.3585* (.2207)
Human capital	.2545*** (.0849)	.1162 (.1123)	.1582 (.1216)	.1950** (.0976)	-.0173 (.0788)	-.0347 (.0728)	-.0108 (.0802)	-.0429 (.0689)
Life expec. (inverse)	-92.03*** (29.48)	-29.150 (43.38)	-47.271 (45.80)	-52.847 (36.36)	14.342 (13.11)	14.392 (13.61)	15.211 (14.43)	16.039 (13.81)
Employme nt rate	-.1348 (.3019)	-.0623 (.2589)	-.1237 (.3558)	-.188696 (.2909)	.0800 (.2780)	.1515 (.2092)	.1190 (.2548)	.2302 (.2659)
Financial developme nt	.9897*** (.3472)	.2498 (.5657)	.2561 (.6863)	.6114 (.4487)	.3585 (.3275)	.2397 (.3119)	.3202 (.3217)	.2343 (.3019)
Trade openness	-.0056 (.0742)	-.0167 (.0631)	-.1290 (.1216)	.0859 (.0719)	-.157*** (.0623)	-.1622** (.0678)	-.137*** (.0575)	-.179*** (.0718)
Political stability	.0809** (.0365)	.0735*** (.0271)	.1109*** (.0426)	.0811*** (.0329)	.0153 (.0232)	.0153 (.0271)	.0153 (.0244)	.0140 (.0253)
Control of corruption	.1230* (.0716)	.0665 (.0598)	.1139 (.0737)	.0959 (.0604)	.0654* (.0349)	.0749* (.0441)	.0661 (.0412)	.0571 (.0446
Rule of law	-.0739 (.0669)	.0671* (.0417)	-.1047 (.0708)	-.0698 (.0549)	.0385 (.0546)	.0626 (.0475)	.0509 (.0483)	.0587 (.0463)
Constant	4.853*** (1.425)	2.1128 (2.081)	3.9992 ** (1.891)	3.3602** (1.680)	.2818 (.7653)	.1386 (.7536)	.0957 (.7969)	.0020 (.7595)
Countries	98	98	98	98	35	35	35	35
Observatio n	296	296	296	296	105	105	105	105
Numb. of instrument	15	15	15	15	15	15	15	15
Arelano-Bond AR(1)	0.38 [.700]	-1.48 [.138]	-1.01 [.313]	-1.39 [.165]	-0.73 [.470]	-0.57 [.570]	-0.47 [.640]	-0.54 [.590]
Sargan	53.10 [.01]	24.35 [.01]	10.50 [.05]	25.34 [.01]	10.61 [.01]	8.76 [.013]	8.55 [.014]	9.96 [.007]
Hansen	21.69 [.00]	14.82 [.01]	7.61 [.022]	18.29 [.01}	7.06 [.0})	4.96 [.084]	4.62 [.099]	4.79 [.09)[
Diff.Hanse (excluding	6.89 [.001]	0.00 -	0.00 -		0.02 [.88]	0.00		

*Notes: Notes: ***,** and * indicate that the coefficient is significantly different from 0 at the 1, 5, and 10 percent significance level, respectively. Standard errors are in parenthesis unless otherwise indicated. In brackets are the p-values for post-estimation tests of autocorrelation and overidentification.*

.

Second, the results of the regressions confirm that the productive structure of a country is a strong driver of GDP per capita in developing countries. For this group, the estimates (1b – 1d) show that the coefficients associated with different metrics of economic complexity are positive and significant at the 1% level. This is consistent with the findings in Hidalgo and Hausmann (2009). The complexity outlook index has also a positive but marginally significant effect, suggesting that countries with capabilities like those required to produce in complex sectors are likely to enjoy higher level of income. For SSA, on the contrary, estimates in columns (2b – 2d) indicate that the coefficients associated with each of the three variables used as proxies for a country's productive structure have an unexpected negative sign but are not statistically significant at all standard levels. In other words, the productive knowledge and capabilities embedded in SSA countries 'economies have no significant effects on their GDP per capita dynamics., suggesting the presence of a trap of development stasis.

Third the results in Table 5.3 also confirm that other variables are statistically significant as drivers of GDP per capita. Starting with the level of GDP per capita in the initial period, this variable is positive and statistically significant across all two groups and regressions, suggesting a strong persistence in the series of GDP per capita across developing countries. The investment rate is another significant determinant of GDP per capita, especially when some measure of economic complexity is included in the model, suggesting that the effect of increase in investment on GDP per capita is higher in economies with more diversified capabilities. Human capital is positively and significantly associated with high GDP per capita only in developing countries. In the subgroup of SSA countries, human capital is negatively associated to the level of GDP per capital, albeit with statistically insignificant effect. It is worth to note that, once measures of economic complexity are included in the regression, the effect of human capital is longer significant across regressions. As argued in Hausmann et al. (2014), this result suggests that the dimension of human development that is relevant to GDP per capita is better measured and captured through metrics of economic complexity. The same can be said for financial development, which has a positive and significant effect on GDP per capita only in development countries, but negative and nonsignificant effect in SSA countries. The effect of this variable become statistically insignificant once measures of economic complexity are accounted for in the growth model. Trade openness have negative effect that is not significantly in developing countries but strongly significant in SSA countries, reflecting the effect of unfavourable terms of trade shocks to which SSA is exposed. Political stability and control of corruption appear to be also associated positively with GDP per capita in developing countries. Improvements in life expectancy contribute positively and significantly to GDP per capita in developing countries, but not in SSA as a specific group.

5.3.2.2. Evaluating the resource curse and trap of development stasis. Growth Determinants

This section presents the regression results for evaluating the presence of the resource curse and/or the trap of development stasis, using the growth regression model. As in the regression for the drivers of GDP per capita, we estimate the model for the full sample of developing countries [(1a) – (1d)] and for the subgroup of SSA countries [(2a)– (2d)].

Overall, the results show strong heterogeneity in the growth dynamics within the developing countries. Natural resources and country's productive capabilities are both robustly positive and statistically significant drivers of economic growth in developing countries. In the sub- set of SSA countries, the effects of these two key variables on growth are statistically insignificant, suggesting that the region is different when compared to the rest of developing countries.

First, the regression estimates for developing countries show that natural resources are a strong driver of economic growth. The coefficients of natural resource rents are positive and statistically significant at the 1% level. In other words, higher levels of natural resource rents are positively associated with higher growth, In SSA as a stand-alone subgroup, the estimates clearly indicate that natural resources had no statistically significant effect on growth during the period under analysis. The coefficients associated with the natural resource variable have a positive sign, albeit not significant, indicating the absence of adverse effect on growth. In both SSA and developing countries, there is no evidence of a resource curse, and this result is robust to alterations in the conditioning information. It is worthwhile to note the heterogeneous effects of natural resources on growth between SSA and the overall group of developing countries when the productive capabilities are included in the regression. Compared to the baseline regression, there is an increase by a factor of more than 1.7 in the coefficient associated with natural resource rent for developing countries as whole. For SSA, the coefficient is almost unchanged. This result clearly suggests that natural resources have strong positive effect in more complex economies.

Table 5.3. Regression Results: Growth Determinants

	System Generalized Method of Moments (Sys-GMM) Dependent variable: ΔlogGDPpct = logGDPpct - GDPpct-1 (5-year averages)							
	Emerging economies and developing countries				Sub-Saharan African countries			
Variables	(1a)	(1b)	(1c)	(1d)	(2a)	(2b)	(2c)	(d)
GDPpct-1, log	-.0795 *** (.0235)	-.0051 (.0393)	-.0597 (.0376)	-.0475* (.0292)	.0247 (.0230)	.0258 (.0241)	.0255 (.0238)	.0275 .0277
TNR Rents	.0015*** (.00058)	.0025*** (.0006)	.0030*** (.0009)	.0026*** (.0005)	.0008 (.0005)	.0007 (.0010)	.0007 .0007	.0007 .0010
Economic fitness, log		.0506*** (.0161)				-.0033 (.0196)	.0007 (.0007)	
ECI			.1052*** (.0422)				-.0053 (.0317)	
COI				.0430*** (.01648)				-.0026 (.0159)
Investment rate	.0627* (.0348)	.1050*** (.0362)	.0686 (.0491)	.1114*** (.0398)	.0833* (.0502)	.0795* (.0492)	.0802* (.0493)	.0839 (.0533)
Human capital index	.0439*** (.0139)	.0045 (.0212)	.0190 (.0238)	.0274 (.0182)	-.0321* .0196	-.0330 (.0215)	-.0318 (.0199)	-.0342 (.0245)
Life exp. (inverse)	-14.76*** (5.1007)	3.156 (8.459)	-3.208 (9.186)	-3.943 (6.986)	8.27*** (3.131)	8.269 (3.188)	8.32*** (3.195)	8.40*** (3.201)
Employment rate	-.0175 (.0504)	.0031 (.0466()	-.0146 (.0688)	-.0323 (.0515)	.073 (.0520)	.0775 (.0632)	.0762 (.0579)	.0858 (.0976)
Financial develop.	.1508*** (.0599)	-.0600 (.1029)	-.0385 (.1353)	.0463 (.0823)	-.0671 (.5093)	-.0729 (.0963)	-.0692 (.0951)	-.0769 (.1019)
Trade openness	.0011 (.0141)	-.0020 .(0134)	-.0307 (.0250)	.0264* .(0146)	-.0332** (.0160)	-.0335** .0160	-.0322* (.0183)	-.0350** (.0180)
Political stability	.0094 (.0063)	.0072 (.0053)	.0170** (.0083)	.0094 (.0060)	-.006047 (.0076)	-.0060 (.0080)	-.0060 (.0080)	-.0061 (.0079)
Control of corruption	.0254** (.0124)	.0093 (.0117)	.0230 (.0147)	.0178* (.0108)	.0162 (.0157)	.0166 .0150)	.0162 (.0163)	.0155 (.0191)
Rule of law	-.0131 (.0106)	-.0112 (.0078)	-.0216 .(0136)	-.0112 (.0098)	.0231** .0105	0243 .0141	.0238 ** (.0122)	.0247 (.0158)
Constant	.7941*** (.2469)	.0134 (.4007)	.5738 (.3799)	.3821 (.3164)	-.2706 (.1932)	-.2777 (.1994)	-.2810 (.2034)	-.2928 (.2292)
Countries	98	98	98	98	35	35	35	35
Number of Observation	294	294	294	294	105	105	105	105
Number of Instruments	15	15	15	15	15	15	15	15
Arellano-Bond AR(1)	-1.39 [0.164]	-2.48 [0.015]	-2.46 [.014]	-3.14 [.002]	-1.83 [.068]	-1.56 [.110]	-1.60 [.109]	-1.78 [.074]
Sargan	53.59 [.000]	18.81 |.000]	9.75 [.008]	22.18 [.000]	0.05 [.997]	0.00 [.998]	0.01 [.997]	0.01 [.994]
Hansen	27.88 [.000]	15.33 [.001]	7.01 [.030]	20.84 [.000]	0.02 [.999]	0.00 [.998]	.000 {.998]	0.01 [.996]
Diff..(null H exogenous)	8.43 [.015]	15.33 [.001]	7.01 [.030]	20.84 [.000]	0.01 [.996]	.000 [.998]	.000 [.998]	0.01 [.996]

Notes: ***,** and * indicate that the coefficient is significantly different from 0 at the 1, 5, and 10 percent significance level, rctively. Standard errors are in parenthesis unless otherwise indicated. In brackets are the p-value for post-estimation tests.

Second, the results of the regressions confirm that the productive capability of a country is a strong driver of economic growth in developing countries. For this group of countries at large, the estimates (1b – 1d) show that the coefficients associated with the country's economic fitness score, economic complexity index and complexity outlook index are positive and statistically significant at 1% level. Thus, not only the diversity and complexity of capabilities embedded in countries productive structures are important, but their position in the product network matters for growth. In other words, countries with capabilities like those required to produce goods and services in complex or high added-value sectors enjoy faster growth. This is because they have many paths to diversification into high productivity sectors, making it easier for them to achieve productivity-enhancing structural transformation. This result is consistent with findings from previous works (Hausmann et al.; 2014: Stojkoski et al., 2016).

For SSA, on the contrary, estimates in columns (2b – 2d) indicate that the coefficients associated with each of the three variables used as proxies for a country's productive capabilities have an unexpected negative sign but are not statistically significant at all standard levels. In other words, the productive knowledge and capabilities embedded in SSA countries 'economies have no significant effects on their growth dynamics. This result reflects the heterogeneous dynamics of economic complexity (Cristelli et al. 2015), which suggests that there is a threshold21 or a transition zone beyond which economic complexity becomes a main driving force for economic growth. Countries with a level of economic complexity/fitness below this threshold, as is the case for the majority of countries in SSA, are positioned in the chaotic regime of the GDP-Economic Fitness Plan, where growth is predominantly driven by exogenous forces (Cristelli, Tella, Cader et al., 2017; Cristelli, Tacchella, & Pietronero, 2015; Cristelli, Tacchella, Zaccaria, A., & Pietronero, 2014).

Third, an important result that is worth highlighting is the coefficient of lagged GDP per capita in the growth regressions; it represents the conditional convergence coefficient. In the standard regression for the full sample of developing countries, the coefficient is significantly negative at 1% level, suggesting that there is conditional convergence. This is consistent with the prediction of the standard neoclassical growth model, that is, countries close to their steady-state output level will experience a slowdown in growth (Barro, 1991, Caselli et al. 1996). In

[21] Using the analysis in the Fitness – GDP plan, economic complexity studies have estimated this threshold to be around log(Economic Fitness) = 1 (that is an economic fitness score =) (see Cristelli et al., 2014; Cristelli, Tacchella, Cader et al., 20017; Tacchella, Mazzilli, & Pietronero, 2018).

the subset of SSA countries, the coefficients associated with the lag of GDPpc are positive but statistically insignificant, suggesting the absence of convergence effect and meaning that the other right-side variables measure differences in steady-state growth rates.

The introduction of economic complexity in growth modelling has profound consequences on economic convergence property. In fact, once measures of economic complexity (either EF or ECI) are included as determinants of growth, the coefficients associated with the lag of GDP per capita are still negative but not statistically significant, indicating lack of convergence. This result is consistent with previous works by economic complexity scholars (Cristelli, Tacchella, & Pietronero, 2015; Cristelli, Tacchella, Cader et al. 2017) who demonstrate that the distance between the real income of countries and the expected or steady-state one is not directly a measure for the potential of growth of countries. They show that, unless a country's complexity level (Fitness) is higher than a certain threshold, a country will not experience faster growth, regardless of its lower initial income and stock of human capital. This line of analysis shows that the convergence property will hold only for countries in intermediate fitness regime and with income lower than expected[22] .

Fourth, the estimation results confirm that other explanatory variables are important determinants of growth. In the baseline regression for developing countries, the estimates indicate that human capital, financial development, life expectancy and control of corruption are significant drivers of long-term growth with positive effects. When a measure of economic complexity is included in the growth regression, investment rate turns as a significant driver of growth, whereas financial development, human capital and control of corruption and control of corruption become statistically insignificant at all standard levels. Consistent with the findings discussed in Hausmann et al. (2014), this result suggest that economic complexity measures capture well most of the dimensions of financial development, human capital and institutional quality that are relevant to economic growth.

For SSA, the estimates from the baseline regression model show that other statistically significant growth determinants include investment rate, human capital, life expectancy, trade

[22] Cristelli, Tacchella and Pietronero (2015) indicate that he expected level of income, given the level of fitness of a country, is the result of the minimization of the Euclidean distance of the countries from the line weighted by the country GDP

openness, and rule of law. Human capital index, life expectancy and the ratio of trade openness enter the regression with a negative sign, implying that these factors reduce growth of GDP per capita for the countries in the region. For the regressions where alternative measures of a country's productive capabilities are included, no additional variable turns out to be significant.

We note that across all four specifications for SSA, the coefficient on trade openness is robustly significant and has a negative sign, suggesting that trade openness is bad for growth in SSA countries. This result may reflect the perverse effects of globalisation, trade deficits, and unfavourable terms of trade for sub-Saharan countries. It is consistent with the findings reported by Tsangarides (2012) in his investigation of the determinants of growth spells in Africa, where he highlighted the negative role of trade openness and drought and concluded that the continent is different from the rest of the world. We also note that the inverse of life expectancy is robustly significant with a positive sign across specifications, suggesting that life expectancy reduces growth of GDP per capita. This result reflects the demographic transition phase in which many countries in the region are going through. As reported in a previous work, for countries in demographic transition, life expectancy reduces GDP per capita (Cervellati & Sunde, 2011).

5.3.3. Evaluating the underlying assumptions of the estimation method

In this section, we discuss the results of the post-estimation tests regarding the assumptions underpinning the consistency of the system-GMM estimator. First, we use the Arellano-Bond test of the serial correlation of idiosyncratic error terms in levels. The results in tables 5.2 and 5.3 indicate that the null hypothesis of no second-order serial correlation cannot be rejected in all regressions, both in SSA and in developing countries, except in two regressions where economic complexity variables are included in the models for the full sample.

Second, the standard Sargan and Hansen tests of over-identifying restrictions presented in Tables 5.2 indicate that there are some concerns with the validity of the instruments, suggesting that there might be misspecification issues in the regressions for the determinants of GDP per capita. Both Sargan (Not robust, but not weakened by many instruments) and Hansen tests (Robust but weakened by many instruments) reject the null hypothesis of instrument validity at standard levels of significance in all regressions. The results in Table 5.3. for growth regression indicate that both Sargan and Hansen tests reject the null hypothesis of instruments validity in the regressions for developing countries. In the regressions for SSA countries, the null hypothesis o instruments validity cannot be rejected, suggesting that the models are well specified when we isolate SSA as a specific region. These results emphasise the heterogeneity of growth dynamics in the broad sample of developing countries.

While the rejection of the null hypothesis of instruments validity - clearly undesirable - indicates that there is some model misspecification, this is not unusual in the specific context of GDP per capita growth regression. In Bond, Hoeffler, and Temple (2001), the authors highlight this problem and suggested using a more efficient System-GMM estimator that is shown to give more reasonable results than first-differenced GMM in their estimation of an empirical growth model. Bond and co-authors acknowledge that" some techniques are likely to work poorly in this context, and even our preferred estimates are quite imprecise" (p.22). . They point out that, if there is heterogeneity in the slope coefficients, it would invalidate the use of lagged values of serially correlated regressors as instruments. They suggest that developing specifications that allow for some limited heterogeneity in slope coefficients and investigating the extent of such heterogeneity using sub-samples of countries where longer time series are available might give vastly different results.

Given the unavailability of long-time series on growth that could be averaged over an interval of at least 5 years to remove business cycle fluctuations, the next chapter in this thesis uses non-parametric approach following Cristelli, Tacchella and Pietronero (2015) to analyse the hidden potential and dynamics of growth in SSA resource-poor and resource-rich countries. This approach allows to account for the heterogeneity and complexity of the growth dynamics and the transition of countries from one growth regime to another, as they go through separate phases of development process (Castañeda, Pietronero et al., 2022; Sbardella et al. 2018).

5.4. CONCLUDING REMARKS

This chapter sets out to explore the statistical and economic significance of natural resource dependence and country's productive capabilities in driving the dynamics of long-term growth in SSA, taking the whole group of developing countries as a benchmark. To this effect, we unified the two prominent views on growth performance—resource curse and quiescence trap hypotheses—in a regression framework that allows us to estimate the parameters associated with measures of natural resource dependence and country economic complexity, and subsequently evaluate their statistical significance at standard levels. We specified a dynamic panel data model of growth, controlling for various determinants, some of which are proxies for mechanisms believed to be the channels through which natural resources adversely affect growth. Based on the nature of our dataset and good statistical practices from previous seminal empirical contributions on growth regression in a dynamic panel setting, we selected the system-GMM as the suitable method for the estimation of the model.

Overall, our results reveal a clear heterogeneity in the dynamics of long-term growth between SSA and developing countries. First, in both the developing countries and SSA, natural resources are found to be positively linked to growth over the period, with a strongly significant effect in the former group of countries but only marginal in the latter. Nonetheless, our further search for evidence of resource curse via long-term determinants of growth shows that there is a marginally significant adverse effect of natural resource dependence on growth through human capital development in developing countries but not in SSA. Where natural resources interact with financial development and effective control of corruption, a positive effect on growth is found with a marginal effect in developing countries, but a strong effect for SSA when natural resources interact with financial development. Many other factors that drive growth dynamics in developing countries, such as financial intermediary development and human capital, are positively linked to growth in SSA, but their effects are not statistically significant.

Second, and more remarkably, country productive structure, as measured by the diversity and complexity of capabilities embedded in economic systems, is a strong and robust driver of long-term growth in developing countries, thus confirming the findings from previous empirical works reviewed in Section 4.5. In SSA subgroup, however, country productive capabilities are negatively linked to long-term growth, albeit with insignificant coefficient. Neither of the economic complexity metrics (ECI, COI, EF) explains differences in growth across African countries on the south of Sahara. This result is in support of findings from economic complexity research that shows that, for countries whose productive capabilities position them in a low economic fitness regime[23], economic complexity (as measured by fitness score) is a poor predictor of growth, which is predominantly driven in this regime by exogenous forces (Cristelli, Tacchella, & Pietronero, 2015; Cristelli, Tacchella, & Cader, 2017; Tacchella et al. 2018).

Therefore, based on the overall results presented in this paper, we can conclude that what holds back SSA countries and prevents sustained and rapid catch-up growth in their economies is their low endowment of productive capabilities, not their dependence on natural resources. This conclusion, which contrasts with overwhelming existing evidence of the resource curse in SSA, stems from an important modelling innovation we have introduced in the empirical research on the resource curse. By including a novel long-term growth determinant - country's endowment.

The finding that the productive knowledge and capabilities with which a country is endowed positively affect growth in developing countries, but negatively in SSA, raises some concerns about the validity of existing empirical work on the curse of natural resources. It suggests that the underlying empirical growth models used in resource curse literature – which do not account for productive structure – are mis specified and suffer from serious omitted variable bias (see Sbardella et al. 2018;). We discuss these concerns here with the aim of drawing guidance for future empirical research on the curse of natural resources in developing countries. Having established that the country's productive capabilities – the omitted variable in empirical literature on the curse of natural resources—are positively correlated with long-term growth in developing countries, it remains to show that the natural resource variable is correlated with the complexity of the country's productive structure in order to invalidate the evidence of the resource curse on the ground of omitted variable bias (see e.g., Singer & Caves, 2017). To do this, we show that, as the data suggest in this study, a higher level of natural resource dependence is negatively correlated with economic complexity; that is, countries with a productive structure dominated by the production and export of natural resources are characterised by lower levels of economic complexity (see e.g., Hausmann et al. 2014;

[23] In Cristelli et al. (2014), the authors present the dynamics of country evolution from 1995 to 2012 in the fitness-income plane for SSA countries and five Asian tigers. It appears that most SSA countries are concentrated (and stuck) in the bottom left corner of the chaotic regime (low fitness score). They argue that "in this region, capabilities-driven arguments (and consequently the fitness) compete with several exogenous factors such as civil wars, corruption, natural disasters, famine, epidemics, corruption, which dump and prevent the start of any effective industrialization process" (pp 9-10).

Tacchella, Cristelli et al. 2012). This negative correlation, combined with the positive correlation between economic growth and economic complexity, suggests that the coefficient on natural resources is estimated with a downward bias in a growth regression that omits productive structure as an explanatory variable. In the case of SSA, where productive capabilities are negatively correlated to growth, the coefficient associated with natural resources would be estimated with an upward bias.

The results in Table 5.2 strongly support the evidence of omitted variable bias in previous work on resource work. In the regressions for developing countries, the results show that the coefficients on natural resource rents increase when a measure of productive structure is included in the regression model, suggesting that its effect was picked up in the effect of natural resources. On the contrary, in the regressions for SSA, the coefficients on the natural resource rents variable decrease with the introduction of productive capabilities, indicating that these coefficients were previously estimated with an upward bias. This has an impact on the statistical inference as demonstrated in standard Econometrics books (e.g., Wooldridge, 2010).. Further, it is also easy to show that the omission of a country's productive capabilities has profound consequences for the estimates of coefficients on other growth determinants included in the regression.

As reported in several papers, there is a significant positive relationship between economic complexity on the one hand and human capital, institutions, investment in technology, and trade openness on the other (see Hausmann et al.2014; Leite et al. 2023; Rivera et al. 2023; Nguyen et al., 2022). This positive correlation between economic complexity – the omitted variable—and these other growth determinants, combined with the positively significant effect of economic complexity on growth, suggests that estimates of coefficients associated with these growth determinants are inconsistent and upward biased in a regression that omits the role of economic complexity in modelling growth. This is clear from the results presented in tables 5.2 and 5.3 where we see that the coefficients of some variables, such as human capital, financial development, and institutional quality, become statistically insignificant when a measure of a country's economic complexity is included in the regression. This suggests that these proxy variables for growth determinants were just picking up the effect of the economic complexity that was omitted in the baseline regression. model. Future empirical research should consider the role of economic complexity when modelling growth to investigate the presence of the natural resource curse.

CHAPTER 6
CAPABILITIES ENDOWMENT, GROWTH POTENTIAL AND DYNAMICS

6.1. INTRODUCTION

In the preceding chapter, we examined the role of natural resources and productive capabilities in accounting for cross-country differences in GDP per capita and growth dynamics during the growth acceleration period that many resource-poor and resource-rich sub-Saharan countries experienced from the mid-1990. We find that, on one hand, the effect of natural resources on long-run growth was positive but statistically insignificant, thus ruling out the natural resource curse hypothesis. On the other hand, the productive capabilities endowment of countries had a negative effect, albeit not significant, on long-term growth in sub-Saharan countries. This surprising result, however, is hard to generalise given the significant heterogeneity of the countries in SSA and the changing nature of the growth dynamics as argued by economic complexity scholars. The linear regression-based approach employed does not account for the heterogeneity of countries or the changes in growth regimes within individual countries. For this reason, we argued for the use of a non-parametric approach to analyse the growth potential and economic dynamics of individual countries as they transit from one growth regime to another during the different phases of their development.

In this chapter, we attempt to address the second specific question of this PhD research: To which extent are the capabilities embedded in sub-Saharan countries' productive structures systems and their changes over time a constraint or an enabler to their transition from growth acceleration to sustained growth? This question is similar to the one investigated in the growth turning points literature where scholars investigate the factors associated with growth acceleration that is sustained for long period. However, we depart from the parametric approach based on the mainstream growth regression framework and take an evolutionary approach that views a country's competitiveness and ability to produce complex products as an enabler of its transition from growth acceleration to sustained growth.

To address the question above, we use complex network-based metrics referred to as "economic fitness" to quantify the relative competitiveness of individual SSA countries - in terms of the capabilities embedded in their productive systems to produce and export a diversified set of goods and services. The comparison of these individual countries' metrics of economic fitness allows the determination as to whether resource-poor countries tend to have the requisite level of intangible assets for sustaining growth over a long period relative to their counterparts endowed with or dependent on natural resources. Further, following the methodology developed in Cristelli, Tacchella and Pietronero (2015), we combine the fitness metrics with the GDP per capita to explore the growth potential and dynamic patterns of SSA countries as they transition through different growth regimes or remain stuck in poverty trap. We also use the economic fitness metrics to construct a selective predictability scheme (SPS) to forecast growth and its future trajectory following the methodology developed in Tacchella, Mazzilli and Pietronero (2018).

The remainder of this chapter is organised as follows: In Section 2 we present the methods and sources of data. Section 3 presents the empirical results, while Section 4 discusses the results and draws some relevant policy implications.

6.2. METHODS AND MATERIALS

6.2.1. Country's Economic Fitness: Motivation and Definition

In section 5.2.1.2 we defined a metric of economic complexity referred to as "economic fitness of a country," which is a measure of its global competitiveness and ability to produce sophisticated or complex goods and services. According to Cristelli, Tacchella and Petronero (2015); the motivation underlying the economic fitness, as a non-monetary metrics for country competitiveness, hinges on the recent observation that mainstream theories of economic growth appear not to properly describe the origin of the wealth and competitiveness of countries (Cristelli et al., 2013, Hidalgo & Hausmann, 2009; Tacchella et al., 2012). These scholars analysed the export basket of countries and find that it reveals important information on how countries accumulate wealth. "The wealthiest and most competitive economies are usually those which exhibit the highest diversity of export. On the other hand, poorly diversified economies tend to be specialized on those few products which are exported by all other countries." This is what we referred to in the precedent Chapter as "the nestedness" feature of the export basket. While economists agree that specialization and diversification are both involved in the growth and development of the country wealth, empirical observations and machine-learned patterns support the idea that, in a globalized and dynamic scenario, diversification turns to be a far more important element than specialization in the determination of the fitness of an economic system and its potential for sustained growth [Brummitt et al., 2020; Cristelli et al., 2013: Tacchella et al., 2012).

In section 5.2.1.2. we presented the Economic Fitness and Complexity (EFC) algorithm introduced by Tacchella et al. (2012) as a new statistical approach, based on coupled non-linear maps, to quantify the competitiveness (fitness) of countries and the complexity of the products they produce. This novel nonmonetary metrics has been adopted by scholars and organisations (including the World Bank) as a coherent approach to assess the competitiveness of economic systems. In the next section, we show that the economic fitness metrics can be combined with the GDP per capita to assess the hidden growth potential and dynamics.

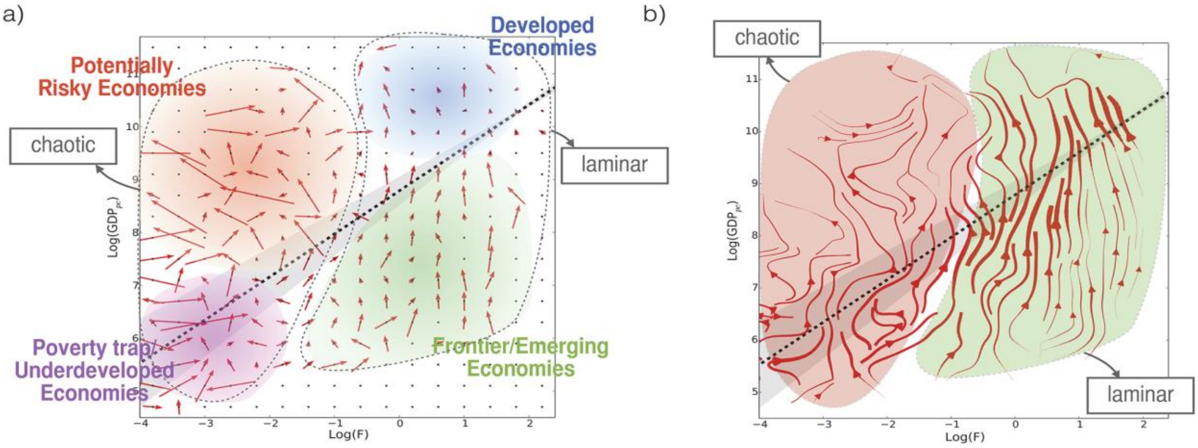
6.2.2. Assessing growth potential and economic dynamics: GDP - Fitness Plane

As discussed in the introductory section, the regression-based parametric approach is particularly appropriate only under the assumption that the economic system responds homogenously to a specific set of independent variables, which is rarely the case in economic systems (Cristelli, Tacchella and Pietronero, 2015). Thus, to further explore the role of economic complexity in driving the growth dynamics and potential of SSA countries, we follow these scholars by adopting the analysis in the Fitness-GDP plane. Further, we predict the future evolution of selected resource-poor and resource-rich SSA economies in comparison to few emerging economies, following the selective predictability scheme (SPS) and forecasting scheme proposed in Tacchella et al. (2018).

The Fitness-GDP plane is a novel analytical framework which allows to visualize the economic dynamics of countries and predict their future evolution. Cristelli and co-authors show that by the means of comparison of non-monetary measure of intangible assets (fitness) with monetary indicators, such as the GDP per capita, one can quantify the hidden growth potential of countries. This comparison defines the fitness-income plane (figure 6.1.) where they observe that country dynamics presents strongly heterogeneous patterns of evolution with different degree of predictability for the future evolution of their economic system.

Depending on the relative value of fitness and GDP per capita, Cristelli and co-authors observe the emergence of different regimes of country evolution and development. They are able to distinguish two main regimes: (i) a laminar-like regime, in which the dynamics appear to be predictable and informative of the country's growth (green and blue shades, where the versors of evolution tend to be parallel in the motion of high GDPpc); and (ii) a chaotic-like regime, in which no clear emergent pattern is observable (purple and red shades where the versors tend to be unevenly directed). A more careful analysis reveals an even richer ecology, and at least four different types of dynamics can be uncovered with different dependencies on fitness (and GDPpc).

Figure 6.1. Heterogenous dynamics of economic complexity



Sources: Cristelli, Tacchella, & Pietronero (2015). Notes: "The four regimes of the heterogeneous dynamics of economic complexity. a) A finer coarse graining of the dynamics highlights two regimes for the dynamics of the evolution of countries in the fitness-income plane. There exists a laminar region in which fitness is the driving force of the growth and the only relevant economic variable to characterize the dynamics of countries. The evolution of countries in this region is highly predictable. There is also a second regime, which is chaotic and characterized by a low level of predictability. In the laminar regime we also find two different kinds of evolution patterns for the emergent countries (intermediate fitness and income lower than expected) and developed ones, respectively. Similarly, we can observe two sub-regimes in the chaotic zone for the intermediate and high-income countries but with lower fitness (risky economies) and for the low income with lower fitness (poverty trap). b) we report a continuous interpolation of the coarse-grained dynamics to better illustrate the two regimes of predictability" (p.5)

As illustrated in figure 6.1. above, the economic complexity approach does not claim that the productive capabilities embedded in a country's economic system are the only drivers of growth dynamics. The point is to show that endogenous and exogenous factors impact the dynamics of growth differently, depending on the development stage of an economy. For countries in the laminar zone of the GDPpc-Fitness plane, growth is driven by capabilities as measured through fitness metrics. Whereas for countries in a chaotic regime (poverty trap and risky zones), the dynamic of growth tends to be driven by external or exogenous factors, such as international trade shocks, global economic trends, geopolitical shifts, etc. Unless these countries improve their competitiveness through accumulation and upgrading of productive capabilities, they will not transition in the growth-sustaining regime no matter how high their GDP per capita is.

6.2.3. Selective predictability scheme and GDP forecasting

Cristelli, Tacchella and Pietronero (2015) emphatically stress that the heterogeneity of the income dynamics in relation to the value of the fitness has several conceptual and practical consequences on how to conduct a predictive scheme for the trajectory evolution of economic systems. Pointing out that regression approaches are not effective in such a heterogeneous scenario, they propose to define a selective predictability scheme (SPS) in which the degree of predictability of the economic dynamics depends on the specific position in the income-fitness plane. Notably, the SPS is inspired by the so-called method of analogues, and through a measure of concentration it delimits predictability regions inside the Fitness-Income plane. For details on steps for defining the SPS, we refer interested readers to Cristelli, Tacchella, Cader et al., 2017).

As pointed out by Cristelli and co-authors, the SPS faces issues which are close to the problem of forecasting the evolution of dynamical systems (i.e. atmosphere, climate, wind, ocean dynamics, and weather forecast, etc) when the laws of motion are unknown. Thus, in their paper intituled “A dynamical systems approach to gross domestic product forecasting,” Tacchella, Mazzilli and Pietronero (2018) provide a more scientific basis for economic growth forecasting by combining the economic fitness metrics with techniques from dynamical systems. Their model is based on effectively representing economic growth as a two-dimensional dynamical system, defined by GDP per capita and ‘fitness.’ We refer interested readers to the original paper for details on the steps of the forecasting scheme.

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6.2.4. Data Sources

The economic fitness of country metrics provides an effective measure of its productive structure complexity and the relative competitiveness of its economy by extracting the information encoded in the products and services, which the country produces and exports. Naturally, the world trade data on exports is adequate to construct the bipartite country-product network and derive the binary matrix M_{cp}. Saltarelli et al. (2020) investigate to what extent export is a proxy for domestic production and find that export mirrors remarkably well domestic production for manufacturing sectors or sectors related to physical goods. Export data is available through the publicly accessible UN COMTRADE database. This database provides bilateral declarations of export flows (in US dollars) for each product, categorized in the Harmonized System international classification, and aggregated on a yearly basis. The export data offers the advantages of being standardized and homogeneous while synthetically providing a much stronger signal of competitiveness than internal demand; as such it does not suffer many of the most problematic limitations of other macroeconomic observables (Tacchella, Mazzilli & Pietronero, 2018).

The economic fitness data we use in this paper is from different data sets depending on their suitability for the analysis being conducted. First, for purpose of comparing and ranking SSA countries according to the complexity of their economic system, we use the data made available through the Economic Fitness and Complexity repository (www.efcdata.cref.it) made available by the Centro di Studi e Ricera Enrico Femi. This repository provides a publicly accessible dataset on fitness and complexity of products computed using an integrated database (formerly known as Universal Database), which covers the aggregation of the services and physical goods into a comprehensive dataset with the highest available homogeneity. Unlike most reference databases used in economic complexity research that only include the flow of physical goods, the integrated database was derived by implementing machine learning techniques to reconstruct the export flow of services, and them combining them to the export flow of the physical goods. This procedure generates a more complete picture of a country's development and global competitiveness[24] (For details, see Patelli et al., 2022). The temporal coverage of

[24] Stojkoski et al.(2016) report that not only goods but also services are important for predicting the rate at which countries will grow. More importantly, they show that diversification of service exports and its sophistication can provide an additional route for economic growth in both developing and developed countries. [See also results from Zaccaria et al. (2018).

the integrated dataset runs from 1996 to 2018, spanning slightly more than two decades, and covers 124 sectors of which 97 are physical goods (HS92 2-digits classification) and 27 are services.

For the rest of the analysis, we use the Economic Fitness data available both at the World Bank Website (https://datacatalog.worldbank.org/dataset/economic-fitness) and at Luciano Pietronero research group on economic fitness website. Pietronero group's website also provide data on the fitness of industrial sectors and is endowed with tools for data visualisation that can be customized. This economic fitness data has been computed using the reference database for economic fitness and complexity. The reference database is the BACI data set released by CEPII and that is grounded on UN COMTRADE raw data. The BACI dataset is the result of reconciliation procedure of the UN COMTRADE which fixes the inconsistencies between import and export flows, see [Gaulier et al., 2010] for details. This data set provides all yearly trade volumes, expressed in current USD, between pairs of more than 200 countries and covering 5000 products classified according to a six-digit code (categorization: Harmonized System 2007). The economic fitness of countries data has been computed using products aggregated at 4-digit level (HS-2007). At this level, there are approximately 1,150 products exported by at least one country (discarding those products for which all trade flows are zero). Countries are filtered out according to a population and total export volume threshold. Over the period from 1995-2015, this procedure selects approximately 149 countries. which account for more than 95% of world GDP.

Considering the less diversified nature of the SSA countries under investigation and their small export volumes, we also use the economic fitness data computed by applying a new and stable estimation method of country economic fitness and product complexity (Servedio et al. 2018). According to the authors of this paper, the economic fitness score resulting from this new method is well defined for those countries that have low export volumes; for these countries, the original metric had their fitness tending to zero. This feature makes the "new" EFC data more suitable for analysing and comparing countries' growth dynamics and future evolution.

6.3. EMPIRICAL RESULTS

In this sub-section, we first present the results of the economic fitness of SSA countries. We present the average economic fitness ranking for the entire twenty-three-year period (1996-

2018), the change in rankings between two specific years (1996 and 2018) and the time evolution of the fitness rankings. The second sub-section presents the results of the overall countries ‘economic dynamics in the fitness-GDP per capita plane, as well as the growth trajectories of some selected countries. These empirical results are discussed in the third sub-section.

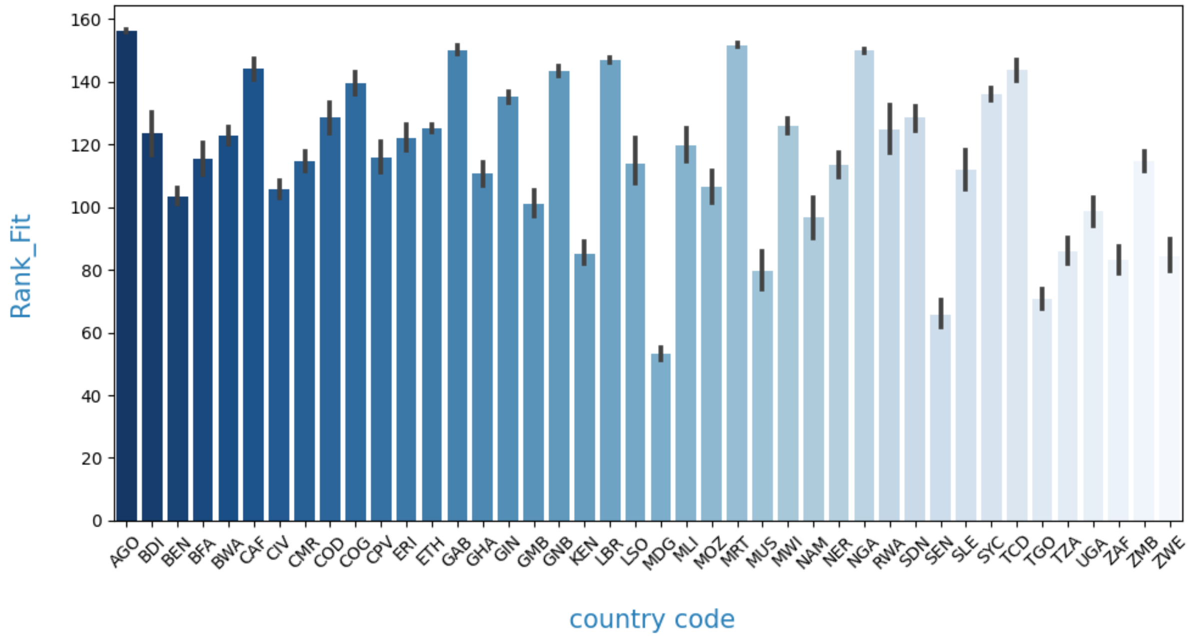
6.3.1. Economic fitness of countries

The economic fitness of countries represents a synthetic measure of the degree of relative competitiveness in terms of the capabilities embedded in their economic system for the production and export of products and services. It is both a measure of a country’s diversification and ability to produce and export complex goods on a globally competitive basis. “Countries with the highest levels of economic fitness have capabilities to produce a diverse portfolio of products, ability to upgrade into ever-increasing complex goods, tend to have more predictable long-term growth, and to attain good competitive position relative to other countries.” Whereas “countries with low economic fitness levels tend to suffer from poverty, low capabilities, less predictable growth, low value-addition, and trouble upgrading and diversifying faster than other countries” (World Bank Metadata Glossary).

We use data on the economic fitness of countries which are computed from the universal economic fitness databse available at the Fermi Centre: www.cref.it. This dataset runs from 1996 to 2018 and covers 160 countries (major world traders) of which 43 are from sub-Saharan Africa. The database is endowed with a publicly accessible code which we obtain to verify the accuracy of the computed metrics. We report in figure 6.2 the average economic fitness ranking of SSA countries for the 1996-2018 period.

Overall, SSA is characterised by low economic fitness scores, with Madagascar emerging as the highest ranked economy in the region (55th out of 160 ranked countries) and Angola being in the bottom ranking (157th out of 160 ranked countries). The majority of SSA countries are positioned in the fourth quartile of world economic fitness ranking distribution, suggesting that their economies are relatively less competitive in terms of the capabilities embedded in their economic systems for the production and export of goods and services in complex sectors associated with higher productivity.

Figure 6.2. SSA countries: average economic fitness ranking in the world.



Source: Our analysis from data available in the Economic Fitness and Complexity repository (www.efcdata.cref.it). Notes :The height of the histogram bar corresponds each to economic fitness rank of the country. Angola is ranked in the 157th position out of 160 ranked countries.

Within the region, resource-rich countries appear in general to be the less competitive ones, producing and exporting products in few low complexity sectors such as oil and gas, mineral products, and other raw materials**.** By sub-Saharan standard**,** few resource-poor countries such as Madagascar, Senegal, Togo, Mauritius, and Kenya have managed to accumulate and upgrade their productive structures, diversifying their economies across low to medium complexity sectors. This is reflected in their higher average ranking over the period. For example, a microscopic examination of the universal binary bipartite matrix $M_{160x124}$ shows that, for the years 1996 and 2018, Madagascar has a revealed comparative advantage equal or greater than one (RCA $\geq$ 1) in 31 and 36 sectors respectively out of 124 physical goods and service sectors considered in total; this is comparable to Vietnam which had RCA $\geq$ 1 in 31 and 38 sectors for the same period, albeit in relatively higher complexity sectors. Moreover, Madagascar has an RCA $\geq$ 1 in about 9 service sectors out of 27 considered. These include intermediate and low complexity service sectors such as construction abroad, consulting, technical, trade-related and other business, manufacturing services and goods for processing inside, other passenger transport, postal and courier, telecommunications services, government goods and services, sea and air transport, etc. The same strategy of developing complex service sectors as a way of diversifying the economy to sustain growth and development can be also observed in the cases of other SSA countries, such as Kenya, Mauritius, Senegal, Tanzania and Togo, which have more than 30 sectors with RCA ≥ 1 in 2018.

The average economic fitness ranking hides important changes over the period. To identify countries that have improved their relative global competitiveness, we present in table 6.1 the World ranking of SSA[25] and the change in their positions between 1996 and 2018. As already shown in figure 6.2 above, the top countries in SSA with the highest economic fitness score are Madagascar, Senegal, Togo, Mauritius and South Africa. Except for South Africa, these are resource-poor countries. The least competitive countries in the region include Angola. Mauritania, Gabon, Nigeria, Liberia, Central African Republic, all resource-rich countries except Liberia.

The world economic fitness ranking indicates that, while the majority of SSA countries remain positioned in the lower quartile of the world ranking distribution, few countries have made a long jump in the region. These include Rwanda, Burundi, Lesotho, Mauritius, and Senegal (all natural resource-poor economies). In particular, Rwanda gained 48 places in the World ranking, moving from 150th in 1996 to 102nd in 2018, mainly due to its diversification in non-traditional agricultural products and service sectors. For Rwanda, this resulted not only in the increase of its comparative advantage from 6 to 25 sectors over the twenty-two-year period but also in the diversification of its economy into 8 service sectors with RCA ≥ 1 by 2018. Similarly, Mauritius moved from 95th to 62nd mainly due both to its export promotion strategy through the export processing zones and to the diversification in manufacturing-based service sectors. The country has now a comparative advantage in service sectors in more than half of all sectors in which it has RCA ≥ 1. Likewise, Senegal climbed the economic fitness ranking from 93rd in 1996 to 63rd in 2018. This great achievement is to be credited to a deliberate diversification strategy by investing in agricultural value chains and service sectors. As expected for commodity-dependent countries such as Rwanda and Senegal, this diversification enabled a gradual move to higher value-added economic sectors and improved their ability to export a diversified basket of products to a larger set of trade partners.

[25] In Table 6.1., countries marked with (*) are resource-rich countries.

Table 6. 1. Economic Fitness Ranking and change (1996-2018): SSA countries

Countries	SSA Average Ranking	World Ranking (1996)	World Ranking (2018)	World Ranking Gain
Angola*	42	156	157	-1
Benin	12	111	95	16
Botswana*	25	131	120	11
Burkina. Faso	21	116	123	-7
Burundi	26	148	103	45
Cabo Verde	22	94	126	-32
Cote d'Ivoire	13	104	112	-8
Cameroon*	19	110	110	0
Cent.Af.Rep*	37	146	121	25
Chad*	36	136	155	-19
Congo Rep.*	34	125	149	-24
Congo DR*	31	101	142	-41
Eritrea	40	132	136	-4
Ethiopia	24	129	122	7
Gabon*	39	153	146	7
Gambia	11	113	98	15
Ghana*	15	117	100	17
Guinea*	32	138	128	10
Guinea Bissau	35	142	144	-2
Kenya	7	97	79	25
Lesotho	18	151	113	38
Liberia	38	149	145	4
Madagascar	1	53	58	-5
Malawi	29	122	126	-4
Mali	23	112	140	-28
Mauritania*	41	152	159	-7
Mauritius	4	95	62	33
Mozambique	14	89	96	-7
Namibia*	9	127	109	18
Niger*	17	108	124	-16
Nigeria*	38	147	147	0
Rwanda	27	150	102	48
Seychelles	33	130	137	-7
Senegal	2	93	63	30
Sierra. Leone*	16	133	129	4
South Africa*	5	98	83	15
Sudan*	30	106	134	-28
Tanzania*	8	85	77	8
Togo	3	71	81	10
Uganda	10	109	86	23
Zambia*	20	115	107	8
Zimbabwe*	6	78	101	-23

During the same period, many other SSA countries lost steam and dropped positions in the global economic fitness ranking. These include, more notably, the DR Congo (-41), which lost its revealed comparative advantage in medium-complexity sectors, dropping from an already less diversified export basket of 14 to 7 sectors. Other countries with similar losses of positions are Cabo Verde (-33), Sudan (-28), Mali (-28) and Zimbabwe (-23). The latter lost seven sectors in which it had a RCA ≥ 1, from 32 in 1996 to 25 in 2018. Except for Cabo Verde, which is a resource-poor and service-oriented economy that is now running out of steam after decades of sustained growth, the other countries' economies have been devastated by the effects of bad policy choices (Zimbabwe), armed conflicts, terrorism and civil wars (DR Congo, Mali, Sudan).

In Figure 6.3 we present the time evolution of the economic fitness ranking for SSA countries from 1996 to 2018. We can highlight some notable trends that are relevant for understanding the growth trajectories and performance of some countries. As expected from Table 6.1, there are not many upward trend patterns (improvement in ranking over time) among countries in the bottom ranking. Remarkably, most resource-rich economies that recorded historically high growth rates in the 2000s are in this part of the chart; they either remain static in their positions or display a downward trend, as they were losing positions in the ranking over time (e.g. Angola, Chad, Congo, DR Congo, Gabon, Liberia, Mauritania, Nigeria, Sudan and Zimbabwe). After the collapse in commodity prices from 2015, these countries lost steam and started falling or slipping, suggesting that their growth was not genuinely driven by the capabilities endowed in their economic systems.

On the contrary, some resource-poor economies, initially in lower ranking positions (e.g. Rwanda, Burundi, Lesotho, Uganda, Senegal, Central African Republic), have steadily increased their diversification, resulting in a positive trend in their world ranking. More notably, Senegal, Rwanda, and Uganda have now emerged as "improved or established growth performers," owing to the improvement in their relative global competitiveness. The case of Zimbabwe, which was among the in top competitive SSA economies in 1996, illustrates a case of productive structure degradation due mainly to bad policy choices and mismanagement of the economy.

Surprisingly, with their low level of fitness in 1996, Burkina Faso and Ethiopia have emerged in 2019 among "established growth performers" Ethiopia 's growth success, in spite of its still can be attributed to its capacity to maintain or increase its competitiveness in a few mid-complexity manufacturing sectors and crop production, a sector in which the country ranks near the top 20 percent of countries globally, due to the success of its cut flower industry.

With respect to Burkina Faso, a microscopic examination of its fitness score and ranking shows that the country progressively upgraded its productive capabilities, diversifying the economy and more than doubling its fitness score from 1996 to 2003. Burkina Faso climbed the world fitness ranking, from 116th to 83rd in a span of 7 years, before receding in the following period. Combined with the introduction of the then newly discovered gold ores in its export basket, this brought significant payoff in terms of sustained high growth that lasted until the onset of the still ongoing crisis.

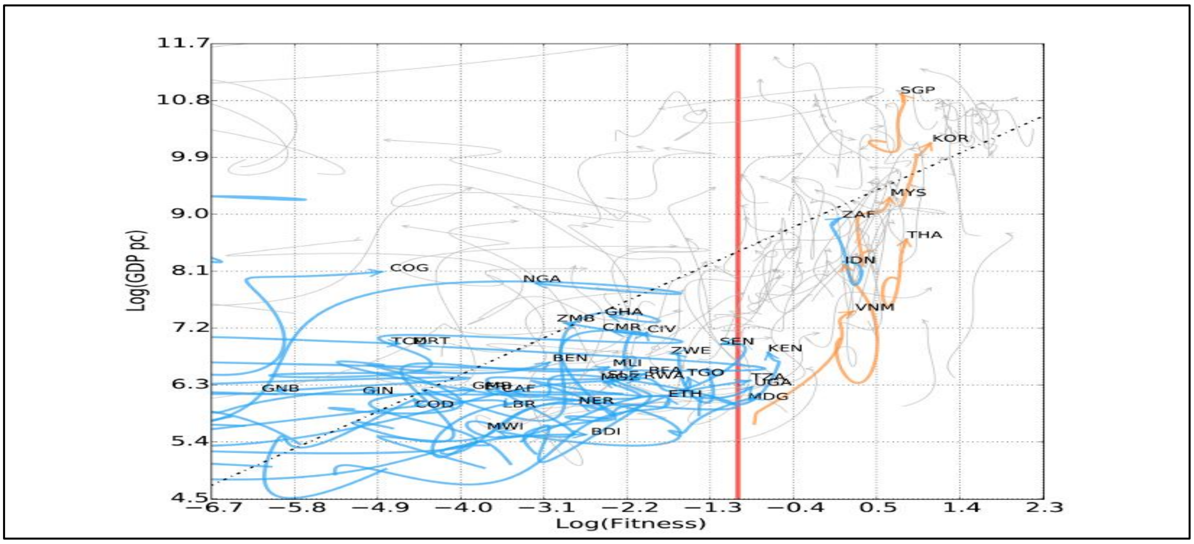
What is clear from the figures above is that resource-poor economies tend to be positioned better than resource-rich ones in terms of their competitiveness as measured by economic fitness. In other words, their productive structures embed a diversified endowment of capabilities that allow them to produce and export a more diversified set of sophisticated or complex products. Resource-poor countries also tend to accumulate and upgrade their productive capabilities more rapidly than their counterparts endowed with rich natural resources, which allow them to take advantage of opportunities for diversification in service sectors as a new route to economic growth. Natural resource economies have a high propensity to rely on their natural-resource-based comparative advantage and on an endowment of capabilities that is too specific and hard to deploy in other sectors with emerging opportunities and good prospects for productivity improvements.

The difference between resource-poor and resource-rich countries les in how their policies and programmes support the processes of capabilities accumulation to facilitate learning and innovation at firm, industry, and country levels. These processes go beyond research an development and include all mechanisms that foster learning processes/ These include: (i)implementation of large-scale programmes to help development of technological capabilities (Ethiopia, Mauritius); (ii) promoting participation in international trade through exports, with the aim to provide incentives to upgrade and expose firms to new ideas, increase access to technology and its embedded know-how, learn about more sophisticated and contested markets (Ethiopia, Kenya, Mauritius, Rwanda, Senegal, South Africa); (iii) attracting foreign direct investment (FDI) that can provide important learning opportunities, invest in R&D and introduce product innovations (Ethiopia, Mauritius, Rwanda, South Africa); (iv) implementation of global value chain (GVC)-oriented policies that facilitate exposure to multinational enterprises (MNEs) and participation in GVCs as sources of knowledge spill overs (Kenya, Lesotho, Mauritius, Rwanda, Senegal, South Africa).

6.3.2. Dynamics in the Fitness - GDP Plane

To analyse the differences among the economic dynamics of SSA countries, we use the Fitness-GDP_{pc} plane, in which it is possible to track simultaneously the evolution of an economic system in terms of its productive capabilities and per capita growth performance. As mentioned above, the comparison of these two non-monetary and monetary measures on this plane gives a visual representation of countries 'development trajectories and can reveal non-trivial information on their hidden growth potential as illustrated in figure 6.3. below.

Figure 6.3. Dynamics in the Income –Fitness plane



Source: *Cristelli et al (2014). Notes: "The dynamics of country evolution from 1995 to 2012 in the fitness-income plane for sub-Saharan countries (light blue trajectories) and five Asian tigers (orange trajectories). The red vertical line defines the transition zone between the chaotic regime (left part of the plane) and the laminar one (right part), while the black dashed line represents the expected level of GDP per capita given the level of fitness. A country below this line is not reflecting, in terms of GDP_{pc}, the complexity of its productive system as measured by the fitness, while countries above the line have a level of GDP_{pc} which can not be explained in terms of the complexity of their productive systems." Source: Cristelli et al* (2014).

The dynamics of SSA countries in the GDP-Fitness plane has been analysed in comparison with the development path of Asian emergent countries for the 1995-2012 period (Cristelli, Tacchella, Zaccaria, & Pietronero (2014). Here we take this analysis as a starting point and develop further by using new fitness data to compare the growth trajectories of some selected SSA countries and forecast their future evolution based on the methods of selective predictability scheme (SPS) presented in Tacchella et al (2018). We report in figure 6.4 the economic dynamics of 46 SSA countries from 1995 to 2012 and the trajectories of the Asian tigers, namely Vietnam (VNM), Thailand (THA), Malaysia (MYS), South Korea (KOR) and Singapore (SGP).

The visualisation of the Fitness-GDP$_{pc}$-coevolution in the plane displays highly heterogeneous dynamics within SSA countries and between the latter and emergent Asian tigers. As highlighted by Cristelli and his collaborators, “most SSA countries are concentrated (and stuck) in the bottom left corner of the chaotic regime” (p.8), which corresponds to the poverty trap and is characterised by turbulent behaviours. They rightly point out that in this zone, “capabilities-driven arguments (and consequently the fitness) compete with several exogenous factors such as civil wars, corruption, natural disasters, famine, epidemics, which dump and prevent the start of any effective industrialization process”(p.9). During the period under their analysis, only Senegal, Kenya, Tanzania, Madagascar, and Uganda were undergoing the first steps of industrialization and the consequent exit from the chaotic regime zone of the poverty trap. The position of these countries during that period, they point out, “was compatible with a scenario in which these five countries will be able to enter into the stream followed by Asian emerging countries like Vietnam and Indonesia in early 1990s”(p.9). At this juncture, it is worth noting that, except for Madagascar, which had undergone severe episodes of political instability, these resource-poor countries that have transitioned out of a chaotic regime are among those SSA nations identified in the World Bank’s Pulse as “established or improved growth performers.”

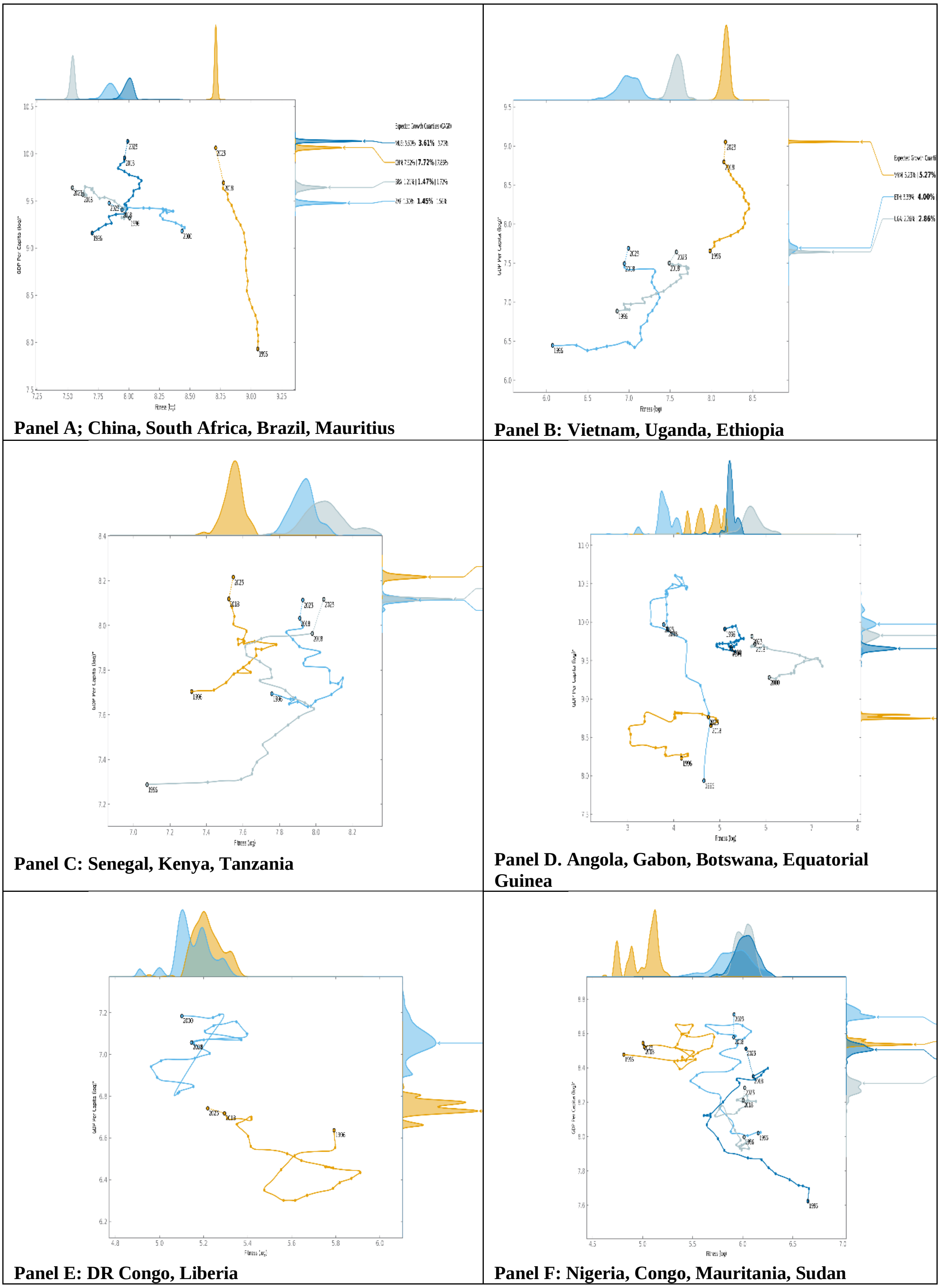
Other countries that were observed as having the potential to undergo an industrialization and development process driven by fitness were Ethiopia and Togo. By 2012, these countries were close enough to the transitional vertical line, and a small increase in the complexity of their productive systems could bring them out of poverty traps and into sustainable transformation of their economies. Zimbabwe is also close to the transition line, but this country is falling back into the poverty trap regime, as illustrated by its generalised decline in competitiveness across all sectors (see Chapter 6).

Without surprise, South Africa was found to be the most mature economy in the SSA region, with a growth and development trajectory in the same regime as that of countries such as India, Malaysia, and Thailand. Its economy is in the laminar region, where fitness is the driving force of growth and the only relevant economic variable to characterise the dynamics of countries (Cristelli, Tacchella, & Pietronero, 2015). Nonetheless, it was highlighted that South Africa faced the risk of incomplete development of its productive system in terms of diversification. As it turned out in the following years, the country got stuck in the so-called middle-income trap as it failed to pursue diversification into high-complexity industrial sectors and even lost competitiveness in the low and medium sectors, in which it used to be ranked in the top-thirty (see Chapter 7).

The heterogeneous dynamics in the Fitness-GPDP plane open a completely new way, which leads to a non-linear approach to forecasting like physical dynamical systems and modern weather forecasting (Cristelli, Tacchella, & Pietronero, 2015; Cristelli, Tacchella et Cader, 2017). We follow the methodology of dynamical systems and use the method of analogues known as Selective Predictability Scheme (SPS) [for details on this methodology, see Tacchella et al (2018)] to contrast the growth trajectories and their future evolution for selected SSA countries. We zoom on resource-rich and resource-poor, which recorded outstanding growth performance from 1995 up until 2015. The economic fitness of countries data spanning from 1996-2018 were used and estimated according to a new methodology developed by Servia et al. (2018), which is suitable for developing countries with small export volumes.

In figure 6.4 we show the growth trajectories and forecasts in the Fitness– GDP_{pc}(ppp) (panels A-F). The full lines show the trajectories between 1996 and 2018, while the 2023 projection is represented with a dashed line. In panel A we contrast South Africa with its comparators. The results show that, unlike China and Mauritius, the growth trajectories of South Africa and Brazil are not moving straight forward in the direction of higher income. Although still in the predictable laminar regime, these two countries are moving into the crowded, risky zone of the Fitness – GDP plane, where most middle-income countries are stuck. Moreover, as illustrated by their marginal probability distributions for fitness and GDPpc in 2023, Brazil and South Africa have a 50% probability of achieving a growth rate larger than 1.47% and 1.45% respectively, compared to China (7.72% and Mauritius (3.61%) whose forecast GDP probability distributions are less dispersed. The evidence presented here supports the findings in prior work that South Africa and Brazil are among the countries that are stuck in the so-called middle-income trap ((Tacchella et al., 2018).

Figure 6.4. Dynamics and forecasts in the GDP–fitness plane s (selected countries)



Panel A; China, South Africa, Brazil, Mauritius

Panel B: Vietnam, Uganda, Ethiopia

Panel C: Senegal, Kenya, Tanzania

Panel D. Angola, Gabon, Botswana, Equatorial Guinea

Panel E: DR Congo, Liberia

Panel F: Nigeria, Congo, Mauritania, Sudan

Notes. Solid lines are trajectories for selected countries from 1996 to 2018. Dashed lines: Forecast 2018-2023. Axes distributions are probability distribution of expected Fitness and GDPpc(PPP) for 2023 obtained as in (Tacchella, et al. 2018). For GDP growth we show first quartile, median and third quartile of expected Compound Annual Growth. [Source: charts generated using a dataset and code provided by Andrea Tacchella, Institute for Complex Systems, CNR, Rome, Italy.

The comparison of growth trajectories and forecasts for SSA resource-rich [panels (D), (E) and (F)] and resource-poor countries [panels (B) and (C)] provides interesting insights about their economic dynamics and future evolution. As illustrated by the growth trajectories representing their dynamics in the fitness-GDP plane, resource-poor countries move towards higher GDP_{pc} levels in a rippling motion like a snail, whereas resource-rich countries move in a sidewinding motion resembling a serpentine pattern. Among resource-rich economies, some countries, such as DR Congo and Liberia (panel E), Congo, Mauritania, Nigeria and Sudan (Panel F) had even moved in circle, remaining in poverty traps, or heading into the risky zone of the chaotic regime. Others, such as Angola, Gabon, and Botswana (Panel D) are marked by S-shaped motion in their economic dynamics, suggesting that the productive capabilities embedded in the productive structures of these countries constrain their transition in prdictble regime of sustained growth and rapid economic convergence.

The growth trajectories of resource-poor countries such as Ethiopia and Uganda (Panel B), Kenya, Senegal, and Tanzania (Panel C) are marked by lesser oscillations and resemble those of Vietnam (Panel B) and China (Panel B) in the 1990s. These dynamics suggest that the productive capabilities embedded in the economic systems of these resource-poor countries is what has enabled their transitioned into a sustained growth regime and their emergence as “established or improved growth perrformers”. As these countries transition into a laminar regime of the Fitness-GDP plane, their economic fitness will increasingly become the main driver of economic growth dynamics.

The heterogeneous dynamics of resource-rich and resource-poor economies in SSA are also reflected in their five-year window growth forecasts. As displayed in their forecast GDP probability distributions, the GDP growth estimates is less precise for both group of countries. However, with their relatively low level of fitness, resource-rich countries are in a much more uncertain situation than their counterpart resource-poor economies. The uncertainty of where they will be in five years is even higher when compared with emerging economies such as China and Vietnam, which are characterised by sustained increases in fitness. This finding is in line with Tacchella et al. (2018) who show that, in general, uncertainty is lower for developed countries that are in laminar regimes and larger for countries with low fitness in chaotic zones.

6.4. CONCLUDING SUMMARY

In this chapter, we considered the relative competitiveness of sub-Saharan resource-rich and resource-poor economies, contrasting their growth dynamics and potential to transition out of chaotic growth zone into sustained growth regime. We addressed the second research question at the core of this PhD thesis: To what extent are the capabilities embedded in sub-Saharan countries' productive structure systems and their changes over time a constraint or an enabler for their transition from growth acceleration to sustained growth?

We address this question in a completely different approach with respect to previous empirical research on natural resource curse. Rather than using the standard regression approach based on aggregative growth modelling, we adopt a data-driven framework known as economic fitness and complexity. This approach aims at extracting information encoded in the export baskets of countries to measure the productive capabilities embedded in their economic systems. Differently from the standard analysis of economic growth determinants, "the drivers of development – in our jargon, capabilities and their network of interaction – play the role of hidden variables whereof information is encoded by the productive system of a country, as proxied by the export basket" (Cristelli, Tacchella, Zaccaria, & Pietronero, 2014, p.14). We used the metrics of country economic fitness and complexity of products to quantify the combined effect of all growth determinants. We followed the analytical framework developed in Cristelli, Tacchella, & Pietronero (2015) to examine the economic dynamics and growth potential of resource-poor and resource-rich economies in SSA. We also used the Selective Predictability Scheme (SPS) developed in Tacchella et al. (2018) to assess the predictability of growth within 5-year horizon, comparing resource-rich and resource-poor economies.

The results from the economic fitness-complexity algorithm show that SSA is house to countries with less complex productive capabilities compared to the rest of the world. There are, however, significant variations with a tendency for resource-poor countries to occupy the top spots in the fitness ranking for the region and to accumulate new capabilities faster than their counterpart endowed with more natural resources. The dynamics in the Income-Fitness plane reveals that, while the majority of SSA countries are trapped in the chaotic growth regime with lower growth potential, resource-poor economies tend to have a higher growth potential. Some resource-poor economies have been able to approach or transit into a more predictable regime where economic fitness become a driving force for economic growth. The growth trajectories of resource-rich economies exhibit erratic behaviour in the shape of serpent motion, sometimes with U-turn patterns, slowing down their economic convergence dynamics and widening the gap in long-term income levels with non-resource countries. Sub-Saharan countries classified as “established growth performers” exhibit growth paths that are like those displayed by emerging economies, such as China and Vietnam in the 1990s.

The findings in this Chapter have significantly direct policy implications for sustaining growth in SSA resource-rich and resource-poor countries in SSA and the overall developing countries. They call for a greater policy focus on supporting the processes of productive capabilities accumulation and innovation at the firm, industry, and country levels. Optimal medium to long term industrial and innovation policies planning through targeted interventions can prove to be an effective tool for diversifying the economy into ever-increasing complexity sectors. The planning of such targeted interventions can be enabled using empirical approaches that are able to forecast industrial sectors upgrading. Such approaches include the standard Product Space and, more recently, machine learning-based methods which can estimate the probability that a country will become (or remain) a globally competitive exporter of a given product within a medium to long term horizon. This is particularly relevant for countries such as South-Africa, Botswana, Equatorial Guinea, Gabon, Mauritius, and Namibia if they should avoid getting in the middle-income trap.

CHAPTER 7

THE PARADOX OF STRUCTURAL CHANGE PATTERNS AND PROSPECTS FOR SUSTAINED GROWTH

7.1. INTRODUCTION

Since the growth accelerations that many countries in SSA experienced from the late 1990s and early 2000s, there has been a growing interest among policymakers and academics in understanding the reasons behind this success and the prospects for its sustainability. Two genuine questions have dominated the empirical research on recent growth acceleration in SSA. The first has been what is driving the rapid growth in SSA after virtually two decades of dismal growth performance. The second and still debated question is whether this rapid growth can be sustained over a relatively long period as witnessed in Asia.

In line with seminal contributions by Herrendorf et al (2014) and Duarte & Restuccia (2010) - who revived the interest in structural transformation by finding that it is a fundamental feature of modern economic growth process - researchers have turned their focus on this wing of economic growth engine to explain growth in Africa. They unanimously found that growth acceleration in SSA has been associated with substantive structural transformation as evidenced by the substantial decline in the share of agriculture in total employment and output (de Vries et al. 2015; Diao, McMillan & Rodrik, 2019; Diao et ai.2017; McMillan & Harttgen, 2014; McMillan, Rodrik & Verduzco-Gallo, 2014). For example, Diao et al. (2017) find that for the eight low-income countries in the Groningen Africa Sector Database (Ethiopia, Ghana, Kenya, Malawi, Nigeria, Senegal, Tanzania, and Zambia), the share of the labour force engaged in agriculture from 2000 to 2010 declined by an average of 9.33 percentage points. Over this same period, the employment share in manufacturing expanded by 1.46 percentage points, and the employment share in services expanded by 6.13 percentage points. As a result of this sectoral resource reallocation from low-productivity agriculture to modern industrial and service sectors with high productivity, labour productivity in these eight low-income countries grew at an unweighted annual average of 2.8 percent; structural transformation accounted for 56 percent of this labour productivity growth. This is in the same proportions reported in de Vries et al. (2015) and in McMillan & Harttgen (2014).

Having established that growth-accelerating structural transformation has indeed happened in SSA countries, scholars have investigated its patterns in comparison with other developing countries in Asia and Latin America in an attempt to understand the prospects for sustained growth in SSA. Their findings show namely two unexpected results. One, unlike other developing countries, economies in SSA have not seen a significant increase in the share of the labour force employed in the manufacturing sector. Instead, the shift in employment share has been towards the services industry, which historically has been less productive than manufacturing in other countries (de Vries et al.2015; Diao et al.2017; EnMcMillan & Harttgen, 2014). Second, unlike in Asian economies where both within-sector productivity growth and inter-sectoral structural transformation have made a strong and positive contribution to overall productivity growth, countries in SSA experienced decline in labour productivity within modern, non-agricultural sectors such as manufacturing during their growth acceleration period (Diao, Ellis et al., 2021; Diao, McMillan & Rodrik, 2019: McMillan & Zeufack, 2022).

The patterns of structural transformation in SSA countries have raised deep concerns about the unexpected way in which the economies of the region are developing, largely bypassing industrialisation. These concerns are particularly stirred by scholars and organizations who strongly hold that manufacturing-led growth is the primary route for job creation, poverty reduction, and rapid growth in developing countries (ACET, 2014; MacMillan & Rodrik, 2015; OECD, AfDB, UNDP, & UNECA, 2013; UNIDO, 2009). Thus, as to the second question of whether SSA countries can sustain rapid growth, these scholars and organizations stand on the pessimistic mainly due to "servicification" of economies and what they view as poor prospects for industrialisation.

However, while the predictions of these scholars turned out to be true, as evidenced by the brutal growth deceleration by 2015 in the majority of SSA countries, comprising mostly natural resource-rich economies, a handful of the resource-poor economies remain on the impressive per capita growth convergence path they have been on since early 2000s. The taxonomy of growth in SSA presented in the World Bank African Pulse (October 2019), just before the COVID-19, indicates that 10 countries in the region continued to have annual average growth rates in 2015-2019 that exceeded the top tercile of the regional growth distribution in 1995-2008. These countries are categorized as "established growth performers" (Burkina Faso, Ethiopia, Rwanda, Tanzania, and Uganda) and improved growth performers (Côte d'Ivoire, Ghana, Guinea, Kenya, Senegal). Except for Ghana and Tanzania, these top growth performers in SSA are resource-poor countries. The IMF economic forecasts for SSA (October 2022) (see **Appendix B**: **Medium- Term Economic Forecast for SSA**). show that these countries were expected to remain on the high growth trajectory, with real GDP growth exceeding 5 percent. Understanding why this handful of the resource-poor countries are successful in sustaining rapid growth while virtually all resource-rich countries are failing is critical for development policy in SSA.

While the emerging literature on structural transformation in Africa has brough interesting insights for our understanding of growth dynamics and the prospects for its sustainability in SSA countries, existing empirical studies lament about the data reliability and limited coverage of countries in available datasets. These studies rely mostly on the Groningen Africa Sector Database, which provides long time series on value added and persons employed from 1960 for ten main sectors of 11 African countries (Timmer et al.2015). Further, to determine the contributions of sectoral productivity growth to economy-wide productivity growth, virtually all empirical studies on structural transformation in Africa cited so far in this paper rely on a sectoral decomposition used in McMillan & Rodrik (2011). Unfortunately, the majority of these productivity analyses either work with aggregate sectoral data that capture differences in industrial structures in a manner that is too coarse (i.e., by defining broad categories such as agriculture, manufacturing and services) or do not take into account the technical sophistication or complexity of the products and/ or sectors (Hartman et al. 2017). More importantly, these studies do not offer a theoretical or empirical explanations as to why some countries such as those in Africa and Latin America display patterns of structural transformation that are different from the classic patterns observed in Asia and other developed countries during their early phase of development.

The present chapter addresses the third research question at the centre of this PhD research: To what extent are the accumulation of capabilities embedded in productive structures and their upgrading relevant in shaping the patterns of structural transformation and driving the industrial sector competitiveness in sub-Saharan countries? We attempt to solve the paradox about the patterns of structural transformation in SSA countries and their prospects for sustained rapid growth. The objective is to provide a theory-grounded explanation as to why resource-poor economies in SSA tend to experience sustained rapid growth while resource-rich economies are failing.

Building on the concept of capabilities embedded productive structure underpinning the economic complexity approach to growth and development, we delve into the structural transformation of SSA countries in a completely different way than in previous works focusing on this region. First, we use the newly available universal dataset integrating world trade in goods and services at a more disaggregated sectoral levels, covering 124 sectors for 160 countries, of which 43 are from SSA. Second, we use the economic complexity and relatedness-based methods that allow us to quantify the inherent capabilities endowment of each country and to assess the extent to which their dynamics drive the patterns and speed of structural transformation, as well as the industrial competitiveness across different sectors.

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The results presented in this chapter provide new insights about structural transformation and growth in SSA, First, they show that the capabilities embedded in the productive structures and their dynamics are the major forces shaping the patterns and determining the speed of structural transformation in SSA countries. Resource-rich economies tend to have a less diversified endowment of productive knowledge and capabilities which grow relatively slowly over time and constrains their economic diversification. Second, sub-Saharan countries that are categorized as established and improved growth performers tend to display a relatively strong dynamics of productive capabilities accumulation and upgrading, which eases their structural transformation and offers more paths to diversification into complex products associated with higher productivity. Third, the dynamics of capabilities accumulation and upgrading determine the ability of countries to maintain or improve their industrial sectors 'competitiveness. Resource-rich countries tend to change their capability endowment relatively slowly and find it hard to keep their industrial competitiveness across sectors.

The remainder of this paper is organised as follows. Section 2 focuses on methods and materials, describing the metrics of economic complexity and relatedness used to quantify the capabilities embedded in the productive structures of countries and assess their dynamics. A description of the sources of data used to compute these metrics is also provided in this Section. In section 3, we present the empirical results. Section 4 discusses the results and draws some relevant policy

7.2. METHODS AND DATA

7.2.1. Measuring the economic fitness of countries and industrial sectors

To assess the structural transformation, we rely on the change over time in the metrics of country fitness derived in Chapter 6. We recall that economic fitness metrics quantify the complex capabilities embedded in the productive structure of a country, and so naturally, their time evolution provides a robust measure of structural change (Cristelli, Tacchella et al., 2013). The holistic view of a countries' economic fitness can be decomposed into much finer details down to the sector level by considering the diversification and uniqueness of the country's products only within a given industrial sector (Pugliese & Tacchella, 2021). Tacchella, Cristelli et al. (2012) show that the complexity of each sector (and hence its relative 'rank') is endogenous and naturally emerges from the fitness computations.

7.2.2. Measuring opportunities for further diversification and upgrading

The position of a country in the connectedness network of products exported by all countries in the world (Product Space or Product Progression Network) determines the opportunities its productive structure affords for structural transformation and the prospects for its future growth (Hidalgo et al., 2007; Hidalgo, 2009). This is implied by the path-dependency feature of diversification and industry upgrading process. A key summary measure to evaluate the overall position of a country in the product network is the economic Complexity Outlook Index (COI) proposed by Hausmann, Hidalgo et al. (2014). This metrics captures the connectedness of an economy's existing capabilities to drive easy (or hard) diversification into related complex products.

To compute COI, one first needs to calculate the proximity between two products in the product space network and the distance of every product to existing products in the export basket (from 0 to 1). Proximities are calculated based on the notion that if many countries exporting one product are simultaneously able to export another, these two products must rely on many complementary capabilities (Hidalgo et al., 2007). Formally, the proximity of two products i and j, $\phi_{i,j}$, is the minimum between the probability that countries export i given that they already export j and the probability that countries export j given that they already export i:

$$\Phi pp' = \min \{P(Mcp' = /Mcp' = 1), P(Mcp' = 1/Mcp = 1\} \quad (7.1)$$

Which is equivalent to: $\Phi pp' = \frac{\sum c M_{cp} \mathrm{Mcp'}}{\mathbf{max(kp,0kp'0)}}$ (7.2)

The distance between a particular product p and the country's existing productive capabilities (also referred to as capability gap) is calculated as the sum of proximities between p and all the products that country c is currently not exporting, normalised by the sum of proximities between product p and all other products. More formally:

$$d_{cp} = \frac{\sum_{p'.}(1 - M_{cp})\boldsymbol{\Phi}_{pp',}}{\sum_{p'}\boldsymbol{\Phi}_{pp'}} \quad (7.3)$$

Having calculated the proximities and the distance, we can now technically derive the complexity outlook index (COI) as:

$$COI = \sum_{p'}\left(1 - d_{cp'}\right)\left(1 - M_{cp'}\right)PCI_p \quad (7.4)$$

Where PCI is the product complexity index of product p' calculated as in Hidalgo & Hausmann (2009). The term (1−Mcp) ensures that we only count the products that a country is not currently producing. A high COI reflects an abundance of nearby complex products that rely on similar capabilities or know-how as those present in current production. Conversely, a low COI reflects that a country has few products that are a short distance away, so it will find it difficult to acquire new capabilities and increase their economic complexity (Hausmann, Hidalgo et al., 2014).

After summarising the position of each country in the product space, we can examine how this position affects the process of structural transformation at the product and country levels. At the product level, an interesting insight is how much a country could benefit from opening future diversification opportunities by developing a particular product or industry. To this effect, we use the concept of Complexity Outlook Gain (COG), and its metrics as proposed by Hausmann, Hidalgo, et al. (2014) in the Atlas of Economic Complexity. Formally, the complexity outlook gain of product p for country c is defined as:

$$OG_{cp} = \sum_{p'} \frac{\phi_{,pp'}}{\sum_{p'}\phi_{pp'}} * \left(1 - M_{cp'}\right)PCI_{p'} \quad (7.5)$$

The complexity outlook gain accounts for the complexity of the products not being produced in a country and the distance or how close to existing capabilities the new product is. A higher COG implies that a product is in the vicinity of more products and/or of products that are more complex. One should observe rapid structural transformation in countries with many products that exhibit high density or high opportunity outlook gain because such products hold more linkages to other high-complexity products, opening more opportunity for continued diversification.

7.2.3. Data sources

To conduct the analysis of the countries ‘productive structures, this paper uses data on different metrics of economic complexity, namely the economic fitness of countries and industrial sectors, the complexity outlook index (COI) and the complexity outlook gain (COG). Data for the economic fitness of industrial sectors is from Luciano Pietronero’s group on the economic fitness website (www.economic-fitness.com) and covers 147 countries over the period from 1995 to 2014. The website is also endowed with tools for data visualisation that can be customised. The detailed goods export data used to decompose industry into twenty-nine sectors was obtained in the HS6 classification from BACI CEPII (Gaulier & Zignago, 2010). The data was originally compiled by the United Nations Statistical Division (COMTRADE), and BACI reconciles the declarations of the exporter and the importer through a harmonisation procedure that extends the number of countries for which trade data are available as compared to the original dataset. BACI provides bilateral values and quantities of exports at the HS 6-digit product disaggregation for more than 200 countries, with over 5.000 products for a country (in its most detailed version) between.

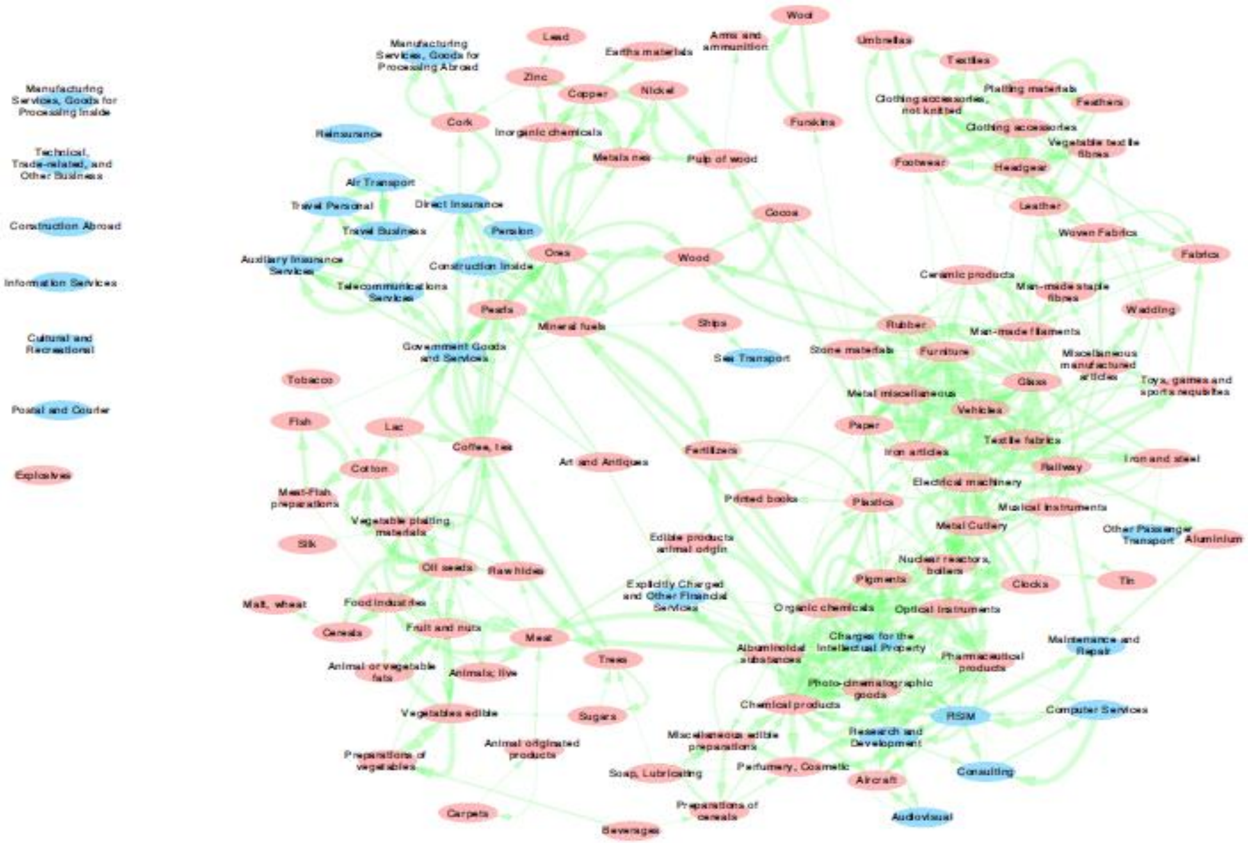
Data on the economic fitness of countries and the complexity of products (goods and services). The complexity outlook index and complexity outlook gain are from the integrated dataset for economic complexity available through the Economic Fitness and Complexity repository (www.efcdata.cref.it) hosted by the Centro di Studi e Ricera Enrico Femi. This repository provides a publicly accessible dataset on key metrics of economic complexity computed using an integrated database (formerly known as Universal Database), which covers the period from 1996 to 2018 for 160 countries, of which 43 are in SSA. The database also provides data on the revealed comparative advantage (RCA) of each country for each product it exports, as well as the binary product network matrix M160x124, corresponding to 160 countries and 124 sectors (97 physical goods and 27 services).

Patelli et al. (2022) present the methodology followed to construct the integrated database of economic complexity. It is in the same vein as the previous works that aim at providing a complete picture of national specialisation patterns and thus offer a more comprehensive view of inter- and intra-sectoral resource reallocation dynamics and opportunities for strategic diversification in the global production network (Mishra et al. 2020; Zaccaria et al. 2018; Stojkoski et al. 2016). Unlike most reference databases used in economic complexity research that only include the flow of physical goods, the integrated database is derived by combining physical goods with services.

The flow of services is derived using machine learning techniques to reconstruct the export flow of 27 service sectors from the International Monetary Fund's Balance of Payments (BPM6) classification of disaggregated data on credit accounts of services. As mentioned above, the detailed goods export data was originally obtained in the HS6 classification from BACI CEPII. Since the trade data on goods and services is combined to produce the integrated database, and since there are only 27 categories of services, the BACI data is used in its "chaptered" format which instead has only 97 categories. This is particularly important to make the two data as compatible as possible before being combined with each other to construct the universal binary matrix Mcp (Mishra et al. 2020).

To support the technical quality of the integrated database, Patelli et al (2022) compute the Product Progression Network (PPN), a statistically validated network of relatedness between economic sectors (Figure 6.1). Here relatedness is understood as a measure of the overlap among the capabilities needed to produce the products in these sectors. They argue that the PPN offers two main advantages over the other commonly network representation approaches to relatedness, such as the Product Space and the Taxonomy Network:(i) the time evolution is explicitly taken into account, permitting the construction of a directed network of sectors, and (ii) each link is statistically validated by comparing its weight against a distribution arising from a suitable null model.

Figure 7.1. Product progression network



Notes: The statistically validated network of sectors. Goods are in pink, while Services are in light blue. The width of the links is proportional to the number of statistically validated time intervals.(Source: https://efcdata.cref.it/ and Patelli et al.(2022)).

As shown in figure 7.1, the network structure exhibits the sane features as the ones identified earlier in the Product Space Network (Hidalgo et al., 2007). Patelli et al. (2022) observe that on the bottom right of the PPN there appears a High-Tech cluster or community containing both high Complexity Goods and Services. Going counterclockwise, immediately above there are all the Heavy Industries and then Textile related sectors. Few other clusters collect the mineral Raw Materials and the Vegetable and the living Materials. These sectors show a lower degree of connectivity, indicating that countries specialized in these sectors rarely jump to more complex industries. Further, they note that the Services are not strongly dispersed but are not forming a single block of nodes. Moreover, High-Tech related Services, those associated to royalties and R&D, are strongly connected with the high Complexity sectors.

Regarding only the services, the group of transport nodes creates a cluster per se. Finally, with respect to the connectedness of nodes, they note that the statistical nature of the construction of the network allows that a few nodes are not connected to any elements because their links are not found to be statistically relevant. They argue that a lower percentile threshold may connect them at the price that the final network will be less statistically significant with more likely erroneous inferences.

7.3. EMPIRICAL RESULTS

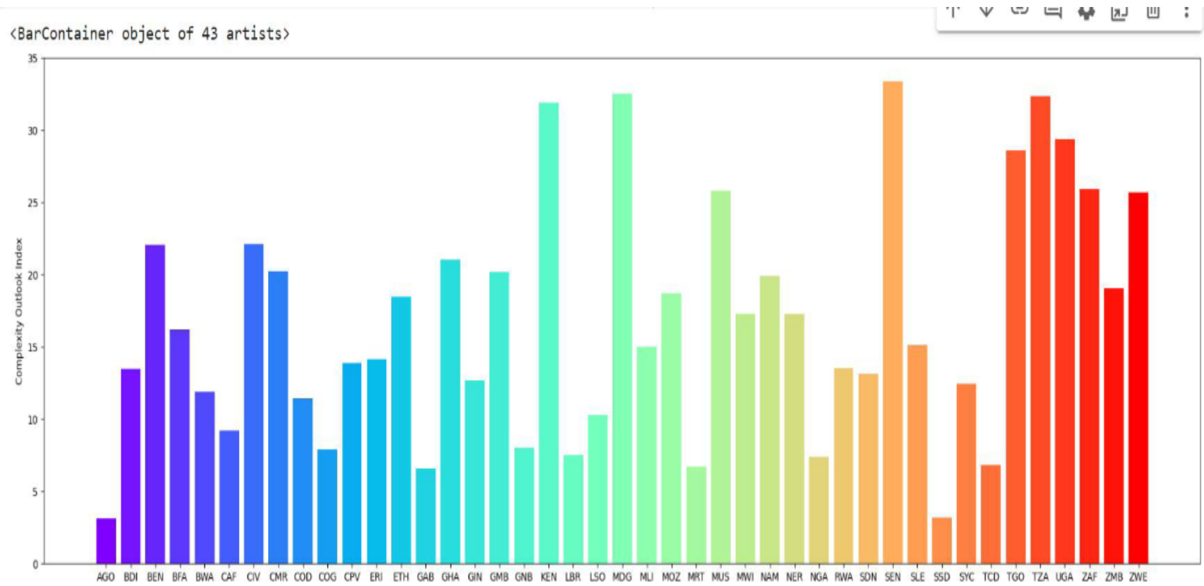
This section presents the results on the diversity and complexity of SSA countries ‘productive systems and their dynamics from 1996 to 2018. We begin by assessing their overall competitiveness based on both diversity of export baskets and overall economic fitness metrics. Next, we analyse the opportunities for structural transformation afforded by each country’s position in the network of sectors ‘relatedness using the metrics of complexity outlook index and complexity outlook gain computed from the integrated dataset. Lastly, we decompose the holistic view of economic fitness presented above into much finer details down to the sector level by presenting the sectoral fitness, which is a measure of competitiveness at industrial sector level.

7.3.1. Diversity and complexity of productive systems

As a first proxy for unveiling the productive knowledge or capabilities embedded in countries ‘productive structures, we look at the diversity of the products they export with revealed comparative advantage (RCA ≥ 1). Although insufficient, the diversity metric is a necessary and relevant information to understand the trading competitiveness of countries (Mariani et al. 2015; Hausmann, Hidalgo et al. 2014). Using the integrated dataset and applying relation ( ) on the binary network matrix Mcp defined in (4.1), we obtain the diversity metric, which is the number of sectors (physical goods and services) in which each country has an RCA ≥ 1 in every year from 1996 to 2018.

Figure 7.2 presents the results in terms of annual average diversity for SSA countries out of 124 sectors. For the period under study, the top countries with the most diversified export basket on the sub-continent are Senegal (33), Tanzania (33), Kenya (32), Madagascar (32), Togo (29) and Uganda (29). Countries with the least diversified export basket are Angola (3), South Sudan (3), Gabon (7), Liberia (7), Mauritania (7) and Nigeria (7). Note that these are all resource-rich countries, with Angola and Nigeria being two of the three largest economies in SSA, alongside South Africa, which competitively exports in only 26 sectors on average over the period.

Figure 7.2. Average diversity of sectors



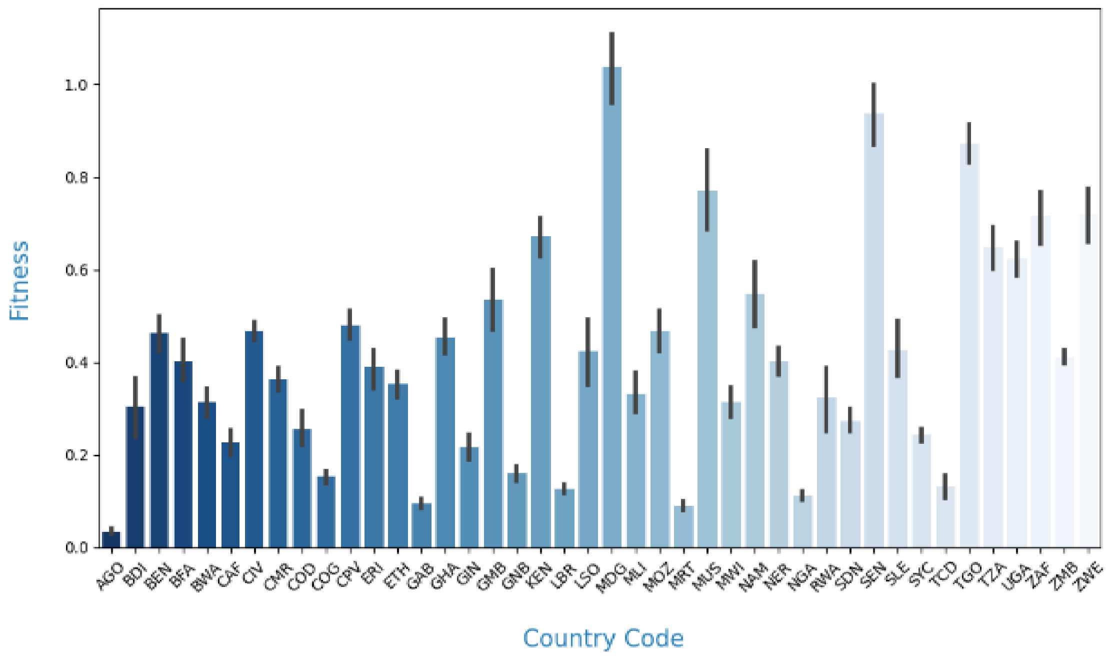
Source: Author's calculations based on integrated database of economic complexity at www.efcdata.cref.it.
Notes: Average export basket diversity (1996-2018) for SSA countries.

The average diversity metrics hide significant variations over time. Annual data on diversity indicate that countries that have remarkably increased the number of sectors in which they export with relative competitiveness include Rwanda (from 4 to 22 in 2016), Senegal (from 25 to 38), Uganda (from 22 to 37 in 2015), Mauritius (from 20 to 32), South Africa (from 16 to 27 in 2017). Countries that have remarkably lost their export basket diversity include

Zimbabwe (from 35 in 2000 to 17), DR Congo (from 13 to 7 in 2018). Despite being the most SSA diversified economy in 1997 with a RCA ≥ 1 in 37 sectors (a diversity comparable to that of Indonesia and higher than that of Vietnam and Malaysia in the same year), Madagascar has slipped on the diversity ground, competitively exporting goods and services in only 30 sectors by 2018. The reasons for differences between countries that have improved their economic diversity and those that lost ground vary, ranging from factors related to political instability, poor institutional governance, inefficient infrastructure facilities or adoption of technology, in particular digital technology which facilitates trade (Prasad et al., 2024).

The diversity metrics used above do not account for export baskets' composition, complexity, or technical sophistication of the products/sectors. To improve this most obvious measure of competitiveness, we turn to the metrics of economic complexity known as economic fitness, which exploit the information related to the sophistication of the export basket and the capabilities required to produce and export a given product (good and service). Using the EF data computed from the integrated dataset (covering all 160 countries from 1996 -2018), we derive the average economic fitness for SSA countries and their ranking (see appendix A). Figure 7.3 presents the results in terms of average EF for the period 1996-2018.

Figure 7.3: Economic Fitness Score for Sun-Saharan Countries

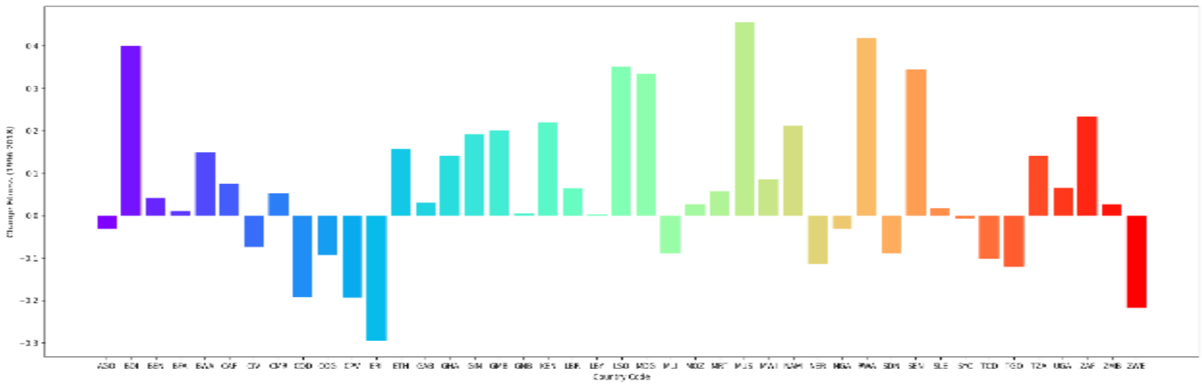


Source: Author's calculations based on Economic Fitness dataset at www.efcdata.cref.it
Notes: Average economic fitness (1996-2018) for SSA countries

The top countries with the highest EF score, that is, the most competitive countries, are Madagascar, Senegal, Togo, Mauritius, and South Africa. Countries with less competitive productive systems, that is, with only a few capabilities embedded in their economic systems, include Angola. Mauritania, Gabon, Nigeria, and Liberia. It is worth noting that though Kenya, Tanzania, and Uganda are among the top six most diversified economies, they are not among the top six countries in terms of their global competitiveness. This is because the composition and sophistication of their export basket are of lower quality than those of the five countries with a higher EF score (See **Appendix D: Sectors Complexity Ranking)**.

To identify which countries have undergone structural transformation, we look at both the changes in economic fitness and its time evolution over the period from 1996 to 2018. The results are presented in Figures 7.4 and 7.5.

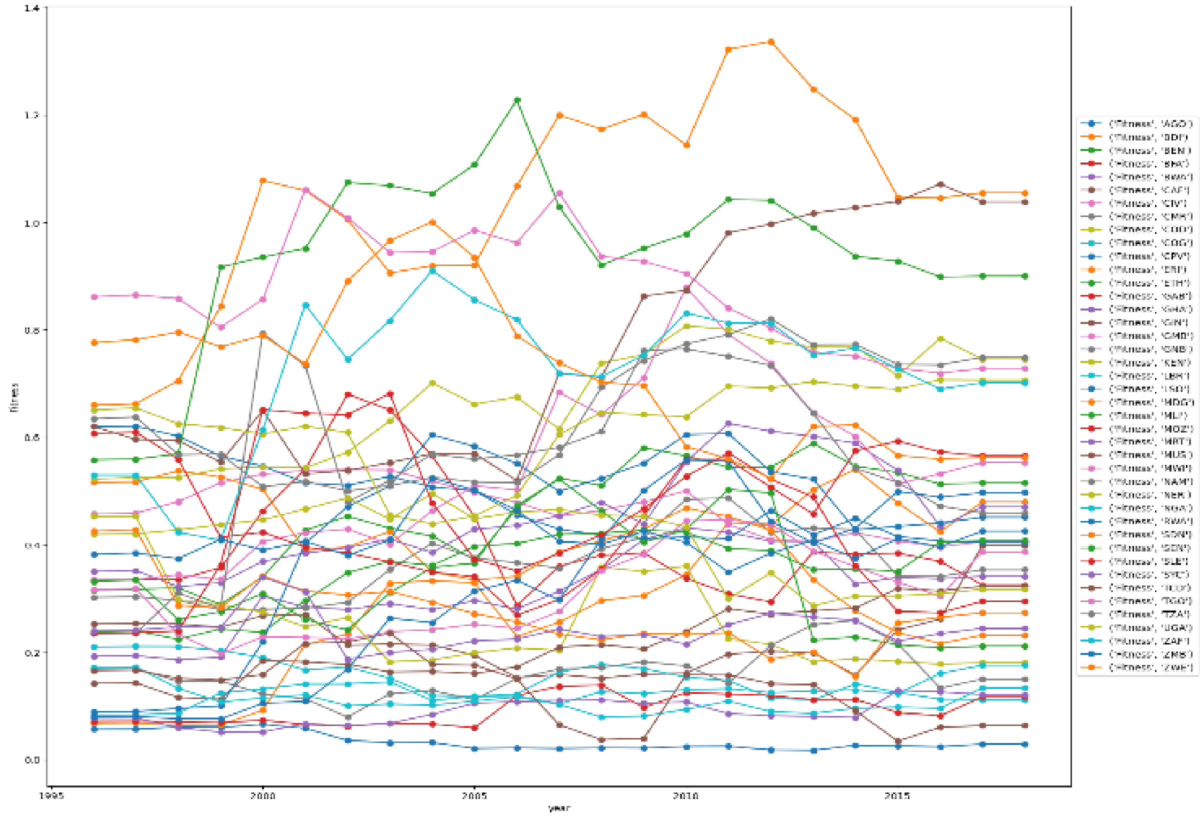
Figure 7.4. Changes in economic fitness (1996 and 2018)



The results presented in Figure 7.4 reveal that 15 countries out of 42 in SSA have experienced remarkably positive or growth-enhancing transformation of their productive structures. These countries have upgraded and increased the diversity of their productive capabilities endowment to diversify into additional sectors, some of which in higher complexity activities. Among these countries, Mauritius, Rwanda, Burundi, Lesotho, Senegal and Madagascar appear to be strong transformers in the region. There are 13 countries that have moved far behind in terms of upgrading and accumulating the capabilities needed to diversify their economies and tra,sform their productive structures. Most significantly, these include Zimbabwe, Eritrea, Cabo Verde, DR Congo, Togo and Niger. These countries have experienced negative or growth-reducing structural transformation. In the middle are the remaining 14 countries with productive structures that have remained relatively unchanged over the period; these include Burkina Faso, Nigeria, Seychelles, Guinea Bissau, Sierra Leone and Mozambique; etc

Figure 7.5 presents the results on the time evolution of individual countries 'economic fitness, which is a measure of how the global competitiveness of a country evolves as it accumulates and develop new productive capabilities to upgrade its productive structure.

Figure 7.5. Time evolution of economic fitness (1996 – 2018)



Notes: Economic interpretation of evolution of the economic fitness "gives a medium-long term information of the development of countries, in this sense, we can consider it as informative on the growth potential of a country" (Cristelli, Tacchella et al., 2013, p.13).

The visualization in figure 7.5 highlights interesting dynamics[26]. Togo and Zimbabwe, which were the top 2 most competitive economies in our initial period (1996-1999) with an EF score of 0.8474 and 0.7807 respectively, run out of steam and fell behind from 2011 (for Togo) and 2006 (for Zimbabwe). They ended the period with an EF score of 0.7261 and 0.5628, implying that these countries have lost their ability to competitively produce and export a diversified set of sophisticated products. The declining trend is also remarkable for countries such as the DR Congo, which lost its competitiveness score year after year from an average of 0.3730 to 0.1803 in 2015-18. Most countries with lower EF score in the initial period show no discerning trend

[26] In Cristelli et al. (2013), the authors argue that "the intensive fitness conveys long-term information of the competitiveness of a country. The intensive metrics is a measure of potential of growth (especially for emerging countries, ……and somehow a measure of resilience and recovery features of economic systems (especially for developed countries) (p.13).

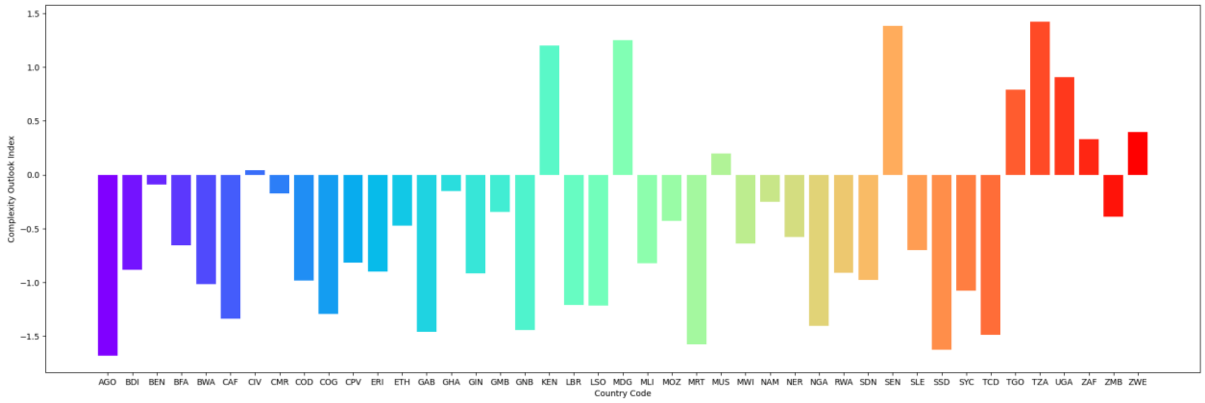
over the period. These include Angola, Central African Republic, Eritrea, Gabon, Liberia. We can also see that there are countries which have steadily increased their economic fitness over the period. These comprise Mauritius, Rwanda, Senegal, Madagascar, South Africa, and Kenya. Rwanda starts from an average EF score of 0.0780 in 1996-99 to end with 0.4956 in 2015-18, surpassing its neighbouring DR Congo. Burkina Faso is another country which improved its relative competitiveness, picking up for five years from 2000 and doubling its EF score by 1996-1998, before levelling off onwards to the initial levels. The improvement in the fitness metrics is informative of the long-term growth potential and resilience features of the economic systems in these countries.

7.3.2. Opportunities for diversification and option value for upgrading.

In this subsection, we turn to the network of sectors (Product Progression Network/Product Space), a representation of relatedness between economic sectors that measures the similarity among the productive capabilities needed to produce goods and services in these sectors. As argued and demonstrated in economic complexity research, the different positions of countries in this network afford them different opportunities for further diversification into ever-more complex products/sectors. We consider the Complexity Outlook Index (COI) and the Complexity Outlook Gain (COG) metrics, which measure the position of a country in the network of sectors and the option value of upgrading into a particular sector, respectively. Figure 7.6 presents the results in terms of average COI for the period covered.

Overall, most SSA countries appear to be positioned on the periphery of the product network, producing and exporting products and services in low-complexity sectors. Only ten SSA countries have a COI that is positive, indicating that their economic systems are relatively embedded with productive capabilities that are similar to those required for the production and export of goods and services in more complex sectors in which they are not currently exporting with competitiveness (RCA $\geq$1). These countries are Tanzania, Senegal, Madagascar, Kenya, Uganda, Togo, Zimbabwe, South Africa, Mauritius, and Côte d'Ivoire. Their position closer to the dense part of the product progression network affords them relatively more paths to diversification into complex sectors and higher potential for productivity-enhancing structural transformation. Whether these countries have fully exploited their potential for growth over the period is another issue. In the case of Madagascar, which is prone to political instability and natural disasters, sustained rapid growth has not been achieved as one would expect.

Figure 7.6. Average complexity outlook index (COI): 1996-20018

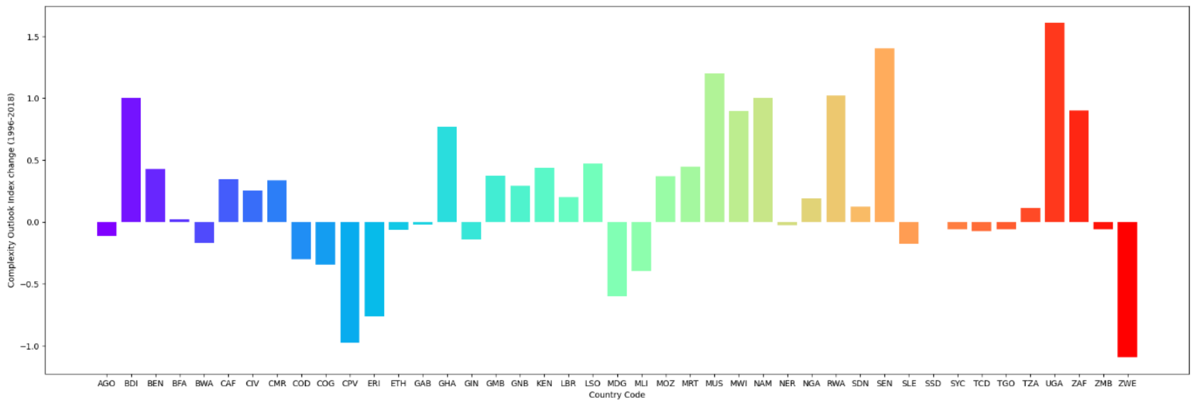


Notes: Economic Complexity Outlook Index (COI) – annual average for the period 1996-2018. Source: Author's calculations from universal COI metrics available through the integrated dataset for economic complexity at www.efcdata.cref.it. There are 10 countries that have a positive economic complexity outlook: Senegal, Tanzania, Uganda, Kenya, Madagascar, Togo, Zimbabwe, South Africa, Mauritius, Cote d'Ivoire. These countries have good prospects to transform structurally and diversify into high productivity/complexity sectors.

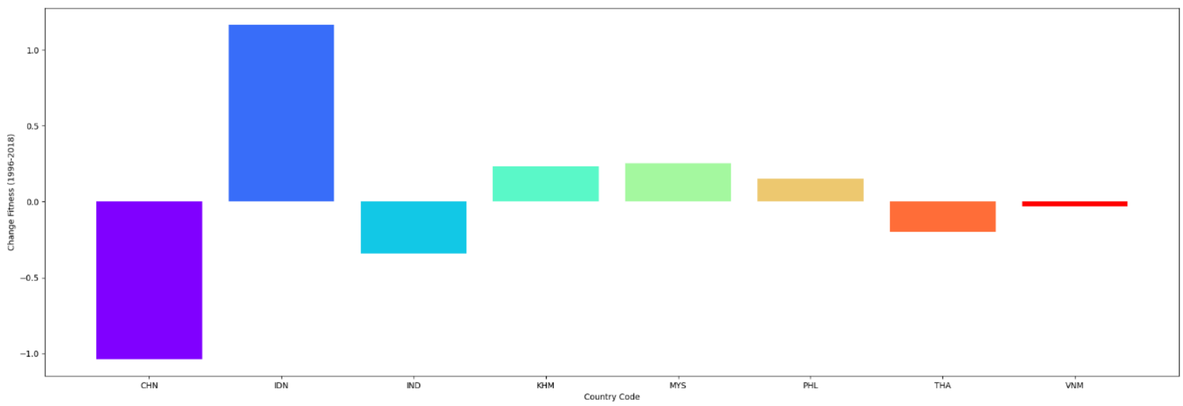
The remaining SSA countries have a negative COI, indicating that their productive capabilities position them far away from the production and export of products in higher-complexity sectors in which they are not currently exporting. These include, more remarkably, Angola, South Sudan, Mauritania, Gabon, Nigeria, the Central African Republic, Chad, Congo, Lesotho, and Liberia, South Sudan. Except for Lesotho, these are all resource-rich economies. Over the period under study, their specialisation remains geared towards the production of few commodities and resource-based products in sectors located in the periphery of the Product Progression Network. These sectors require few specific capabilities that are dissimilar to those needed for the production and export of products located in the core of the network (i.e., complex products). As expected from Hidalgo and Hausman (2009)'s theory of capabilities, sub-Saharan countries with less complex productive structures have found it hard to move into the production of diversified complex products and transform their economies.

The economic complexity literature argues that the position of a country and its dynamics in the network of products and sectors affect its growth performance (Hidalgo et al., 2007; Hidalgo, 2009). Therefore, to get a glance at the dynamics of countries in the product progression network, we look at the change in COI between 1996 and 2018. We compare SSA countries with selected Asian emerging market economies to get insights on their growth prospects. A positive change in COI means that a country has accumulated complementary productive capabilities and has moved further towards the dense areas of the product space with more paths to diversification into higher complexity sectors. Conversely, a negative change in COI implies that the country is not developing the new capabilities required for diversifying into complex products. Such countries may have experienced no structural transformation or have undergone growth-decreasing structural change as they moved towards the production and export of low-productivity products. The exception is for developed countries that generally have a negative COI because they are already producing and exporting most of the complex products in the world (Hausmann et al. 2014). The results are presented in Figure 7.7 Panel A and Panel B for SSA countries and selected Asian emerging economies, respectively.

Figure 7.7. SSA: Change in economic complexity outlook (COI): 1996-2018



Panel A. Sub-Saharan countries



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Panel B: Selected Asian emerging economies

Source: Author's calculations from universal COI metrics available through the integrated dataset for economic complexity. Notes. Change COI) calculated as the difference between average COI for 1996-2000 and 2014-2018

The picture that emerges from the chart in Panel A shows that 24 SSA countries, mostly resource-poor economies, have maintained or improved their economic complexity outlook over the period, having a non-negative change in COI. The remaining 18 countries in the sample experienced worsening economic complexity outlook, with a negative change in their COI which suggests that they have moved further into the production of less complex products.

The patterns of COI change for both SSA and Asia are apparently similar, with a mix of countries that have negative and those with positive dynamics. However, Asian emerging economies that have negative growth in COI include China, India, Thailand and Vietnam, which started diversifying and upgrading their productive structures before the 1990s and are now occupying the dense parts of the sector progression network where most of the high complexity products are located. China reached the world second highest EF score in 2018, while India had the highest COI score throughout the period covered by our dataset. Thailand's economy was already more diversified and complex in 1996, with an EF score ranking 19th in the World. Vietnam' score grew by 88,5% between 1996 and 2018 and the country moved in the world EF ranking from 53rd to 13th. The remaining Asian emerging economies with positive growth in COI (Indonesia, Cambodia, Malaysia and The Philippines) have been progressively diversifying into high complexity sectors over the last two decades.

Conversely, the 18 SSA countries with a negative change in their COI (Angola, Botswana, Burkina Faso, Chad, DR Congo, Republic of Congo, Cabo Verde, Eritrea, Ethiopia, Guinea, Madagascar, Mali, Niger, Sierra Leone, Seychelle, Togo, Zambia and Zimbabwe) are those that have not upgraded their productive structures in order to diversify into the production of higher complexity products which they are not currently exporting. This suggests that these countries have lost competitiveness in some of the sectors in which they had a comparative advantage greater than one and remain on their highly specialized paths in low complexity sectors. The presence of Botswana and Cabo Verde in this group indicates that these two countries are running out of steam prematurely after decades of sustained growth. So is Madagascar, the most competitive economy in SSA, which has been losing ground on competitiveness front without having fully realised its growth potential.

The sizable number of SSA countries which have a positive change in COI include remarkably countries such as Burundi, Ghana, Malawi, Mauritius, Namibia, Rwanda, Senegal, Uganda and South Africa. Five of these countries have experienced rapid sustained growth, starting with Mauritius and the four of the five SSA "established growth performers" (see figure 1.2). Although the productive capabilities of these countries still position them in the periphery of the product network, the positive change in their patterns of specialization suggests that they are on the path followed by Asian emerging economies, increasingly developing productive capabilities similar to those needed to produce and export a diversified set of more complex products.

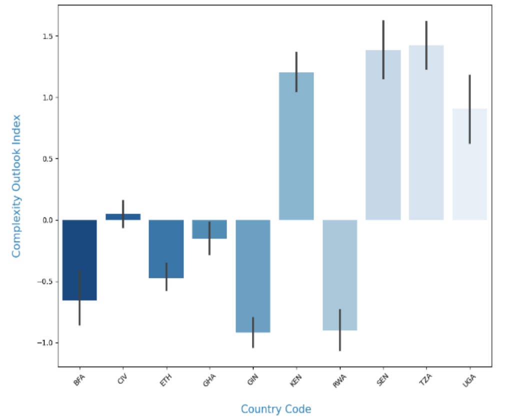
The key factor underlying the differences between Asian emerging economies and SSA countries is the ability to master and accumulate new and more complex capabilities as reflected in the diversification and sophistication of their export basket. This accumulation is policy induced and not the result of the market. For example, starting from the early 1980s, the accumulation of complex capabilities allowed China to acquire RCA in the export of both labour-intensive products (following its factor abundance) and sophisticated products manufactured through learning. Teece (2017) underlines the role of learning in Southeast Asian countries, thanks to the investment of resources by multinational enterprises (MNEs) that spurred the improvement of local firms ‘capabilities. Public policy was used to encourage the creation of relationships between local firms and MNEs that had incentives to improve capabilities at local suppliers in low-wage countries in order to reduce their own costs while maintaining quality. As a result, local firms successfully became strategic complementary to MNEs in manufacturing; in some cases, they successfully graduated from supplier to competitor (e.g., Acer in Taiwan and Samsung in Korea). The role of manufacturing export promotion through government intervention is also squarely emphasised by Rodrik (2014). He shows that the East and Southeast Asian countries explicitly targeted the building of highly competitive manufacturing industries for their export markets, using second-best strategies through a variety of policy tools, including direct subsidies for exports (South Korea and Taiwan), subsidies to foreign investors (Singapore), special economic zones, and subsidies to exporters (China).

7.3.3. Economic Complexity Outlook and Prospects for Sustained Growth

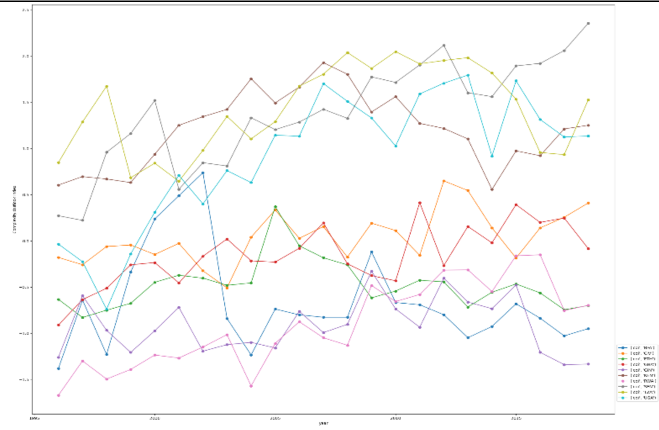
For these countries that have increased their complexity outlook index, the question is whether they can sustain the growth acceleration as the emerging Asian economies have successfully done. To gain further insights into the question of whether some SSA countries could sustained rapid growth or improve their prospects for sustained rapidgrowth, we look at their positions in the product network and the time evolution of their COI. To this effect, we consider three categories of SSA countries according to their growth resilience over the period 1995–2019.

These are “established and improved growth performers”, countries that are “slipping or falling behind” and countries that are “stuck in the middle”(see figure 1.2). We present in figure 7.8. the results for each category of growth resilience.

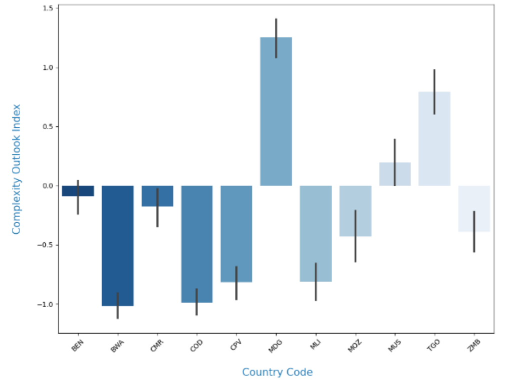
Figure 7.8. Average economic complexity outlook (COI) and time evolution by growth resilience categories



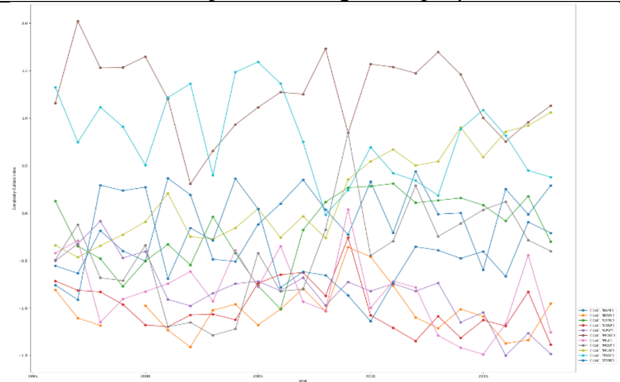
Panel A1. Average COI (1996-2018) for established and improved SSA growth perform



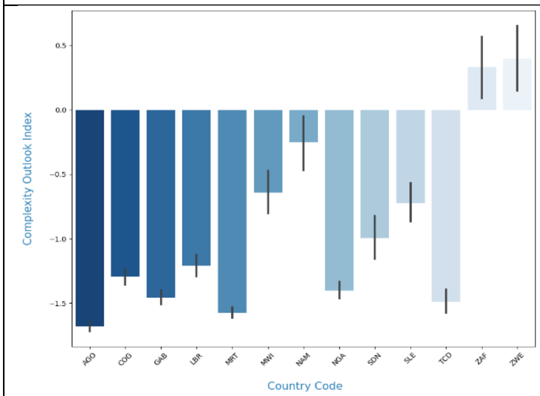
Panel A2. Time evolution of COI (1996-2018) for established and improved SSA growth performers



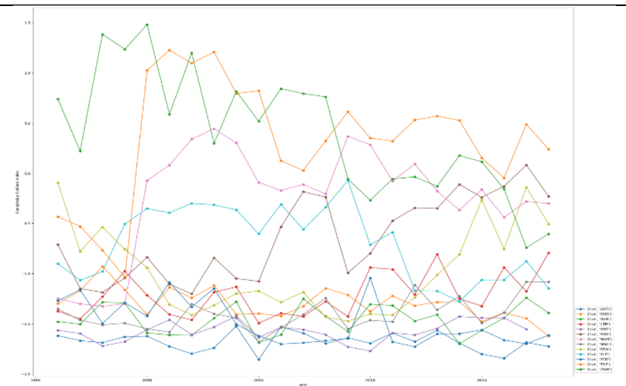
Panel B1. Average COI (1996-2018) for SSA countries stuck in the middle of growth distribution



Panel B2. Time evolution of COI (1996-2018) for SSA countries that are stuck in the middle of growth distribution



Panel C1. Average COI (1996-2018) for SSA countries that are falling behind or slipping



Panel C2. Time evolution of COI for SSA countries that are falling behind or slipping

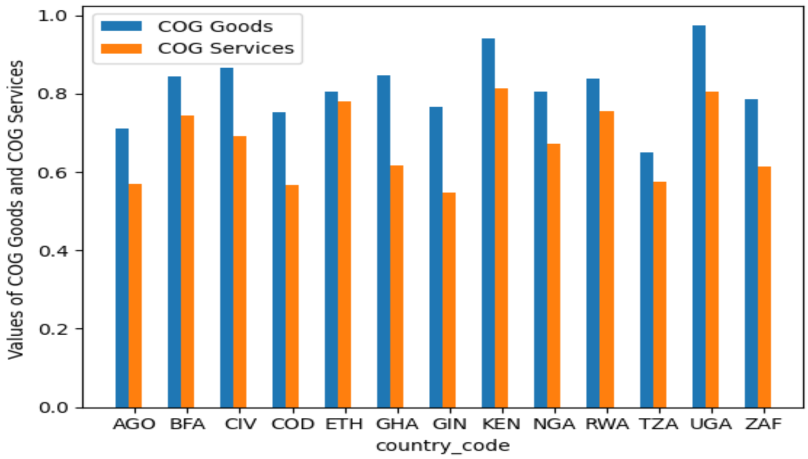
The picture that emerges suggests that five of the countries that are categorised as "established or improved growth performers" (Panel A) are relatively better positioned in the product network, having a positive COI which suggests that their productive capabilities locate them in the proximity of relatively complex sectors. Moreover, the time evolution of their COI exhibits a steady upward trend, indicating that these countries are on the path followed by Asian emerging economies, increasingly developing productive capabilities similar to those needed to produce and export more sophisticated products. These countries are Kenya, Senegal, Tanzania, Uganda, and, to some extent, Cote d'Ivoire. The average position of the other five countries (Burkina Faso, Ethopia, Ghana, Guinea and Rwanda) shows that they are still positioned in the periphery of the sector network (having negative COI), far from high-complexity sectors. Nevertheless, Ethiopia, Ghana, and Rwanda have steadily increased their COI over the period, while the COI for Burkina Faso and Guinea has been fluctuating, showing no trend of improvement. This suggests that the improvement in growth performance observed for these two countries is not genuine and may not be sustained.

Countries that are "falling behind or slipping" (Panel C) are characterised by low COI and/or a downward trend in its dynamics over the period. Except for Liberia and Malawi, the remaining 11 countries in this category are resource-rich countries (Angola, Chad, Congo, Gabon, Mauritania, Namibia, Nigeria, Sudan, Sierra Leone, South Africa, and Zimbabwe). These countries either have a small and less diversified endowment of productive capabilities or they have not upgraded their capabilities to the level required to be able to continue diversifying into ever-increasing complexity sectors (South Africa and Zimbabwe). Unless these resource-rich countries break the dependency path in their capabilities accumulation and diversification processes or improve their national innovation system (more so for South Africa and Zimbabwe), their prospects for sustained growth remain bleak.

In the middle (Panel B) are countries that are stuck. Except for Madagascar, Mauritius, and Togo that have an average positive COI for the period, the remaining 8 countries in this group are still positioned in the periphery of the product network, specialising in the production and export of few products and services in low complexity sectors. These countries include Benin, Botswana, Cameroon, DR Congo, Cabo Verde, Mali, Mozambique, Zambia). As noted earlier, Botswana and Cabo Verde seem to be running out of steam and are in need of capabilities upgrading to diversify their economies and boost economic growth. The remaining resource-poor and resource-rich in this category and to accumulate productive capabilities required to move into the dense area of the product space where most complex products/sectors are located.

Finally, for some selected SSA countries, we look at the opportunity value for the strategic option of diversifying and upgrading into industrial sectors (physical goods only) versus the option of diversifying and upgrading into service sectors. In other words, which strategic option would have more value for a country in terms of opening more paths to diversification into sectors and products (goods and services) of higher complexity levels? To this effect, we used the Complexity Outlook Gain (COG) and calculated its average for 97 industrial sectors and for 27 service sectors in the year 2018. Figure 7.9 presents the results for selected 13 countries, of which 9 are in the group of "improved and established growth performers", 3 are the largest economies in SSA, and we add DR Congo.

Figure 7.9. Complexity outlook gains (value option) for further diversification in goods and services sectors (selected countries)



Notes: Complexity outlook gain (average for 97 physical goods sectors and for 27 service sectors in the year 2018). The values for selected countries (improved and established growth performers + SSA three largest economies + DR Congo) are shown in the table. Source: Our calculations from the COG data computed using the integrated dataset at www.efcdata.cref.it

Code	Goods	Services
AGO	0.7113	0.5695
BFA	0.8425	0.7444
CIV	0.8649	0.6903
COD	0.7533	0.5668
ETH	0.8048	0.7788
GHA	0.8461	0.6174
GIN	0.765	0.5478
KEN	0.9406	0.8129
NGA	0.8048	0.6716
RWA	0.8377	0.7546
TZA	0.6487	0.5756
UGA	0.9752	0.805
ZAF	0.7851	0.6138

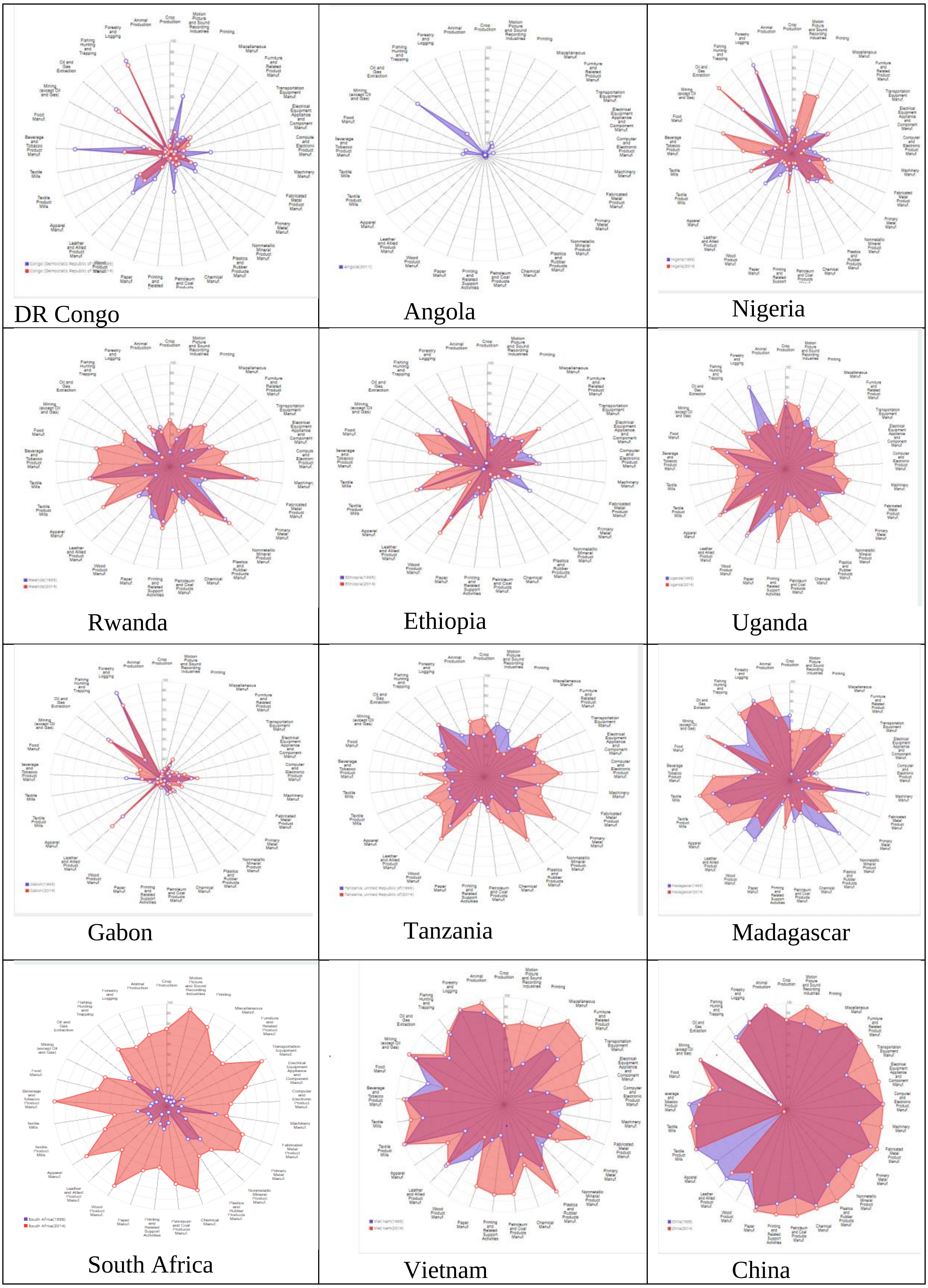
Overall, the results show that the option of diversifying further in industrial sectors is of higher value for all selected countries. That is, developing the productive capabilities needed for the production and export of a typical physical good (say a good with a COG ≥ average COI for the concerned country) will move the country into the vicinity of more complex products, thus opening up more opportunities for further diversification and upgrading of its productive structure. Unless the country specialises in service sectors with a COG greater than the average COG for industrial sectors, it will not significantly improve its economic complexity outlook. Given the small number of such complex service sectors and the technological capabilities they require to competitively produce and export them, specialisation in industrial sectors seems to be more valuable and within the reach of countries in SSA

7.3.4. Fitness of industrial sectors

This section decomposes the holistic view of the countries' economic fitness presented above into much finer details down to the sector level by considering the diversification and uniqueness of the country's products within a given industrial sector. Tacchella et al. (2012) show that the complexity of each sector (and hence its relative 'rank') is endogenous and naturally emerges from the Fitness computations. Building on the online data from Pietronero research group on economic fitness, we select three distinctive groups of SSA countries to which we add China and Vietnam for comparison purpose. The first group includes four of the top natural resource-rich economies in the region (Angola, DR Congo, Gabon and Nigeria). The second group comprises the top three countries in the 1996 sub-Saharan economic fitness ranking (Madagascar, South Africa and Zimbabwe). The third group includes four of the established growth performers (Ethiopia, Rwanda, Tanzania and Uganda).

Following Pugliese and Tacchella (2021), we present the results in figure 5 where we divide the Fitness in 29 industrial sectors. They are arranged counter clockwise by increasing complexity, beginning from the simplest (forestry and logging products) to the most complex (motion picture and sound recording industries). The complexity of each sector (and hence its relative 'rank') is endogenous and naturally emerges from the Fitness computations (Tacchella, et al. 2012). For each sector we show the ranking of the country in that sector's Fitness with respect to the rest of the world (a value of 1 means that the country has the highest Fitness in the world for that sector). To provide a visualisation of the country's industrial dynamics, in the figure we compare the data for 1995 and 2014.

Figure 7.10. Industrial sector fitness (selected countries)



Source: Pietronero Industrial Sector Fitness Data at www.economic-fitness.com. Note: Our customisation using data visualisation tools accessible through the same website. Notes: Red designates the 2014 fitness level, and blue is the level for 1995.

The group of selected natural resource-rich economies share one commonality—hitting the sectoral fitness bottom across all medium-high complexity sectors and losing diversification and competitiveness even in their already thinly distributed industrial base. Despite its diverse mineral resources, DR Congo's industrial structure follows the same patterns, with relatively high concentrations in a few disconnected sectors. The country has suffered losses of competitiveness across all sectors, except forestry and logging and oil and gas extraction, where it appears to have improved competitiveness. The same can be said for Gabon, where only three low complexity sectors dominate the industrial structure with competitiveness ranking in the top 10 percent for forestry and logging sector. Notably interesting trend for Gabon is the dynamic towards diversification into medium complexity sectors albeit with competitiveness level yet under bottom 25 percent.

For the giant Nigeria, while the industrial structure remains thinly distributed across sectors, the country's dynamics show a trend towards diversification in three medium-high complexity sectors (motion picture and sound recording, printing and primary metal manufacturing) where it records a competitiveness level above or on the median. Nigeria lost its already below-median level of competitiveness in low and medium complexity industrial sectors, including in the manufacturing of leather and allied products, non-metallic mineral products, machinery and transportation equipment.

The second group of sub-Saharan top-ranked economic complexity countries had in the mid-1990s industrial structures similar to that of some emerging Asian economies in the 1980S and 1990s. during the same period. Madagascar industrial structure in the mid-1990s resembles that of Vietnam in the same period. However, unlike the latter that significantly increased its overall world economic fitness ranking (moving from 52nd to 17th in 2018) through a rapid diversification into medium-high complexity sectors, Madagascar industrial structure remained fairly static. Even losing ground in several sectors across all complexity levels, such as crop production, Beverage & Tobacco and Textile mills, apparel manufacturing, leather and wood products manufacturing, petroleum and coal products, non-metallic mineral products, machinery manufacturing. Nonetheless, Madagascar has managed to keep its economic complexity ranking through increasing diversification in service sectors (not captured in data here) where it has a RCA ≥ 1 in nine sectors that clustered with manufacturing sectors.

The picture is worse for Zimbabwe and not bright for South Africa which had in the mid-1990s a fairly maturing and distributed industrial structure with competitiveness above the global median in several sectors. As expected from the trend in Zimbabwe's economic fitness ranking over the period, the country's competitiveness has drastically declined across all sectors without exception. This loss of sectoral competitiveness is mainly due to the socio-political crisis that led to the collapse of the country's economy in the 2000s. For South Africa, the only SSA country with a mature industrial structure in 1995 resembling that of advanced economies, we observe significant losses in competitiveness across all sectors, except in the low complexity oil and gas extraction sect South Africa has lost its competitive edge in the export of manufacturing goods, mainly due to its inability to upgrade its technological capabilities in order to keep up with developed economies in the high complexity sectors.

The last group of four sub-Saharan "established growth performers " exhibits a nascent and fairly diversified industrial structure base, with clear dynamics towards medium level complexity sectors where they are climbing the global competitiveness ladder following the footprints of China and Vietnam. These countries, to which we can add Ghana, Kenya, Mauritius and Senegal, distinguish themselves by their targeted industrial and innovation policies aimed at creating the industries of the future by focusing on diversifying the economy in the production of higher complexity goods and services, improving competitiveness in selected industrial sectors, acquiring know-how from global leaders and seeking foreign partners and investment. For example, Lin, Cader and Pietronero (2020) report that amidst a loss of loss of competitiveness in both the most complex sectors (chemicals, machinery, and fabricated metals) simple sectors such as beverage production and mining, Ethiopia adopted in 2010 its first Growth and Transformation Plan (GTP) wherein the country focused on competitiveness in crop, food, and textile production, and growth in animal production, leather, and textiles. As a result, Ethiopia now ranks near the top 20 percent of countries globally in leather and crop production, largely due to the success of its cut flower industry and learning by its industries and firms from global leaders that provide the same goods and services.

7.4. CONCLUDING REMARKS AND KEY LESSONS FOR POLICY

This chapter set out to investigate the third research question at the core of this PhD thesis: To what extent are the capabilities embedded in productive structures and their upgrading relevant in shaping the patterns of structural transformation and driving the industrial sector competitiveness of sub-Saharan countries? Building on the economic complexity approach to development and leveraging on the tools and methods for the analysis of complex systems, we use a novel dataset of goods and services globally traded to analyse the structural transformation of SSA economies. We depart from the traditional sectoral productivity analysis used in previous works on structural transformation in Africa and focus rather on the capabilities embedded in the productive structures of economies and their dynamics.

Overall, the results presented in this paper are in support of the findings in the emerging literature on structural transformation in Africa. Moreover, they provide new insights on the unexpected way in which the patterns of specialisation in SSA countries are moving some economies of the region away from high value-added sectors, rendering bleak their prospects for sustained rapid growth. As such, the results of this paper have important policy implications for inducing productivity and growth-enhancing patterns of structural transformation in SSA.

First, while the results indicate that SSA is home to countries positioned at the bottom of the economic complexity ranking, resource-rich economies tend to have productive structures that embody a smaller endowment of highly specific capabilities that remain less diversified and inadequate for specialising in higher complexity sectors. Second, whereas resource-poor countries tend to show some relative dynamism in the accumulation of new complementary capabilities required to diversify and improve competitiveness in medium to high-complexity sectors, resource-rich countries seem locked into a low-capability trap where the processes of capabilities accumulation are not effective. Third, most SSA countries are positioned in the periphery of the connected product network with fewer paths for diversification and upgrading into higher complexity sectors located in the dense part of the product progression network. Nonetheless, some resource-poor countries have managed to progressively break the path dependency in the accumulation of their productive capabilities, finding it relatively easier to move and transform their productive structures towards the production and export in high complexity sectors associated with higher productivity. Finally, relative to resource-rich economies that remain highly specialised in a few low-complexity sectors, resource-poor countries seem to have purposely adopted the strategies followed by East Asian emerging economies. They tend to diversify their industrial base across sectors and improve their sectoral competitiveness through learning from global leaders, integration in global value chains and partnerships for foreign direct investment (FDI).

The results presented in this paper are consistent with previous works on structural transformation in Africa which focused on sectoral productivity analysis. They complement these works nd bring richer insights due to the quality of fine-grained disaggregated data used and the complex network-based methods applied. In particular, covering virtually all SSA countries, we note that with the exception of Nigeria, the group of 26 (out 43 countries) that have transformed their productive structures includes countries identified in Diao et al (2019)27 as strong structural change performers in SSA. Further, the result that only countries that have managed to accumulate new capabilities and diversify into relatively medium to high complexity sectors have been able to sustain high growth is in support of the finding that growth-enhancing structural transformation is a reward for countries that reallocate resources to sectors associated with higher productivity, such as manufacturing and modern technology-based service sectors (Diao, Ellis et al. 2021; Diao, McMillan & Rodrik, 2019; Diao et ai.2017 ; McMillan & Zeufack, 2022; McMillan & Rodrik, 2014).

More importantly, the results in this paper reverberate the findings from the economic complexity research which places capabilities accumulation at the core of development process and emphatically stresses that a country's productive structure is harbinger of growth, a key determinant in cross-country differences in economic growth performance and development (Hausman & Hidalgo, 2009; Tacchella et al., 2012; Cristelli, Tacchella, Cader et al., 2017). Further by showing that Sub-Saharan resource-rich failed to sustain rapid growth because of their higher specialisation in the production and export of low complexity goods and services, our results support earlier findings that what differentiates countries that succeed to sustain high growth and those that fail is their productive structure and the specific characteristics of the products that they export (Fagerberg & Verspagen, 2021; Felipe et al., 2012, Jarreau & Poncet, 2012). Finally, these results are consistent with the growing body of evidence from studies of economic growth that have shown that the patterns and rates of long-term economic growth are strongly driven by technological upgrading and innovation (Lee et al. 2021, Mohnen & Hall, 2013, Nelson & Winter, 1982). In particular, the series of research papers published in Lee et al. (2021) unanimously point to the technology capabilities upgrading as the major

[27] In this study, the authors identified countries that have undergone strong structural change but experienced negative productivity growth in non-agricultural sector (Ethiopia, Malawi, Rwanda, Senegal and Tanzania) and those with weak structural change (Ghana, Kenya, Nigeria and South Africa).

reason for the rapid growth of the catch-up economies, namely East Asian emerging economies.

The findings in this chapter have important policy implications for growth and development in resource-rich countries and in SSA as a whole. Whereas the policy discourse in SSA countries over the last four decades has been dominated by an excessive focus on ensuring macroeconomic stability under the banner of ensuring "sound growth fundamentals", the findings in this PhD thesis call for a shift of focus towards targeted industrial and innovation policies aimed at developing productive capabilities at the firm, industrial sector and country levels. Consistent with the evidence that the process of technological capability upgrading has failed or remains ineffective in developing countries (Lee. 2019; Lee et all., 2021) mainly due to underinvestment in innovation activities (Cicera & Malony, 2017), this paper advocates for a greater Government role to redress this innovation underperformance while at the same time building the capabilities of public agencies and institutions to accurately diagnose and articulate the problem that is constraining innovation, and subsequently design and implement more effective policies28.

The innovation policy advocated above should go beyond a simple provision of research and development and cover essential dimensions as identified in Cicera and Malony (2017) along the areas of constraints to innovation-related investment and technological adoption. For SSA countries, these dimensions should include: (i) the critical complements to innovation investment needed to realise the high potential returns; (ii) the range of firm capabilities required to undertake innovation and take it to market, and (iii) the required government capabilities for designing and implementing effective innovation policies. With respect to the second dimension in particular, the development of firms 'capabilities can be achieved through a combination of industrial and innovation policies and programmes (Gao, 2021; Pietrobelli, 2021; Cicera et al. 2020). These include: (i) implementation of large-scale programmes to help the development of technological capabilities; (ii) promoting participation in international trade that provides incentives to upgrade and exposure to new ideas, while increasing access to technology and its embedded know-how, learning about more sophisticated and contested

[28] Cicera et al.(2020) offer a Practitioner's Guide to Innovation Policy which provides a rigorous typology of innovation policy instruments, including evidence of impact—and more importantly, the critical conditions in terms of institutional capabilities to successfully implement these policy instruments in developing countries.

markets; (iii) attracting foreign direct investment that can provide important learning opportunities, are more likely to perform R&D and to introduce product innovations; (iv) implementation of global value chain (GVC)-oriented policies that facilitate exposure to multinational enterprises (MNEs) as sources of knowledge spill overs.

In conclusion, this chapter has emphasised the capacity to develop new capabilities for diversifying the economy into ever-increasing complexity sectors and improving relative global competitiveness as an important for productivity-enhancing patterns of structural transformation. It is the difference in this ability which distinguishes SSA countries that sustained rapid growth and those that fail. Future research on growth performance in this region should take into account the role of productive structures in driving differences in growth performance. Case studies at country or sectoral level should be conducted to delve into the processes of business and technological capabilities accumulation and upgrading that are in place in successful transformer countries in SSA with the aim to learn lessons for development policy.

CHAPTER 8
DISCUSSION, POLICY IMPLICATIONS AND SUMMARY CONCLUSION

8.1. DISCUSSION OF RESULTS

This Ph.D. study examines, through the lens of economic complexity and product space, the growth performance of sub-Saharan countries during the recent growth acceleration that SSA experienced from the mid-1990s. Some resource-poor economies have broken the SSA's record of short growth spell duration and remain on the impressive growth convergence path they have been on since the early 2000s. The remaining economies in the region, mostly in resource-rich countries, have been slipping or falling behind since 2015 following the collapse in commodity prices. The main aim of the study was to (i) unravel the respective roles of natural resources and productive capabilities in accounting for rapid growth faltering in SSA; (ii) explore in depth the role of productive capabilities in shaping the patterns of structural transformation and driving the growth potential and dynamics of sub-Saharan resource-poor and resource-rich economies. The central question is: Why do sub-Saharan economies more than often fail to sustain rapid growth despite the tremendous opportunity afforded by the existence of significant sectoral productivity gaps to improve productivity growth? More specifically, we attempted to provide answers to the following three related questions:

1. Why do sub-Saharan countries more than often fail to sustain rapid growth and catch up rapidly—a curse of natural resources or a trap of development stasis?
2. To what extent are the capabilities embedded in sub-Saharan countries' productive structure systems and their changes over time a constraint or an enabler for their transition from growth acceleration to sustained rapid growth?
3. To what extent are the capabilities embedded in productive structures and their upgrading relevant in shaping the patterns of structural transformation and driving the industrial sector competitiveness of sub-Saharan countries?

The analysis of the regression estimates from a system-GMM suggests that natural resources have a positive but statistically insignificant effect on long-term growth in SSA. This effect is positively significant for developing countries. Most strikingly, the analysis suggests that the capabilities embedded in a country's productive structure have a robust and significantly positive effect on GDP per capita and economic growth in developing countries, but not in SSA. Furthermore, the data indicates that SSA is different from the rest of developing countries in terms of other factors driving long-term growth dynamics. Human capital and financial development positively related to growth with a strongly significant effect in developing countries, while they are not significant determinants of long-term growth in SSA. The coefficient trade openness is negative and statistically significant in SSA but not in developing countries, suggesting that outward-oriented trade policies are bad for the countries in the sub-continent, which reflect greater exposure to external shocks in terms of trade.

The analysis of data using non-parametric methods grounded in economic complexity indicates that SSA countries are endowed with a less diversified set of productive capabilities compared to countries in other regions of the world. There are, however, significant variations within SSA, with natural resource-rich economies positioning at the bottom of the World Competitiveness Ranking based on their economic fitness scores. Resource-rich economies also tend to have low growth potential, being in the chaotic zone of the GDP-Fitness plane, where growth is driven by exogenous forces and is unpredictable at the five-year horizon. Sub-Saharan countries that have transitioned out of the chaotic zone and that show higher growth potential include only resource-poor economies and South Africa, which has a mature economy. The data also suggest that resource-poor economies that are categorised by the World Bank as "established or improved growth performers" exhibit patterns of growth dynamics which resemble the paths Asian emerging countries had been on in the 1980s, with predictable growth prospects. On the contrary, countries categorised as "slipping or falling behind" display erratic patterns of growth that are slowing down their economic convergence.

Further scanning of data based on the time evolution of economic complexity and relatedness metrics reveals that growth acceleration in SSA countries has been accompanied by structural transformation in about 26 countries out of 43 included in the sample. However, this structural transformation was growth-enhancing only in 18 of these countries, mostly resource-poor, which upgraded their production structures, moving relatively closer into the dense part of the product progression network where medium- and high-complexity sectors are located. Most of the countries, comprising mostly resource-rich economies, remain on the periphery of the product network, where they are specialised in the production of goods and services in a few low-complexity sectors. Remarkably, these countries have been losing their already low-to-median relative competitiveness in medium-complexity industrial sectors. The data also indicate that resource-poor countries that have diversified into low- and medium-complexity sectors and managed to maintain or improve their industrial competitiveness in these sectors are rewarded with sustained growth.

How can these findings be unpacked and interpreted considering the theoretical and empirical literature reviewed in this study? The finding that the coefficient associated with natural resources is positive but insignificant in the GDP per capita and growth regressions for SSA provides evidence in support of the rejection of the resource curse hypothesis in sub-Saharan countries during the 1996-2018 period. This finding is somehow surprising given the sheer number of empirical works that report evidence of a negative association between natural resources and long-term growth in the countries of the SSA (see **Appendix F: Empirics of Resource Curse in SSA**). Among the papers summarised in this appendix, only one clearly reports a finding of a positive effect of natural resources on growth in a sample of 22 resource-rich SSA countries over the 1998-2016 period (Yang et al. 2019). The remaining nine empirical research papers—at least those covering or overlapping the period under our study – report findings of adverse effects of natural resources on growth or its long-term determinants. This contradiction in findings is due to differences in both the the empirical framework underpinning the growth modelling used and the empirical methodologies (data, samples of countries, estimation methods).

First, all existing research papers in empirical literature on resource curse adopt the standard growth regression model developed by Barro (1991) and Mankiw et al. (1992), which is underpinned by the neoclassical growth models. These models omit or neglect the role of structural transformation, in particular economic complexity, when modelling the growth process. Consequently, given the salience of complex productive capabilities in driving growth, it is fair to say that existing works on resource curse potentially suffer from serious omitted variable bias problem (see Sbardella et al. 2018). Considering the results from our regression, it is evident that the measure of natural resource effect in previous works had been picking up the negative effect of productive capabilities on growth in SSA. Therefore, the inclusion of productive capabilities as a growth determinant to make up for economic complexity is what accounts for the finding of no support for the resource curse hypothesis in our study. Referring to the famous High-Tech Employee Anti - trust litigation case used for illustrating the concept of omitted variable bias by Singer and Caves (2017)[29], we argue that omission of productive capabilities by resource curse researchers when modelling growth "can be detrimental to a regression model. It makes it impossible to accurately tease out even the most fundamental economic relationships in the data and results in biased econometric estimates.

Second, empirically, most studies on the curse of natural resources use annual observations in estimating the long-term relationship between growth and its determinants. This is dictated by the need to have enough time-series observations (T), particularly where a dynamic panel data model is specified, to justify the use of estimation, methods developed for cointegrating vectors in panel settings. However, seminal contributions on growth regression emphasise that yearly time spans are short and inappropriate for studying growth convergence (Bond, Hoeffler, & Temple, 2001; Barro, 2003; Beck, 2000; Caselli et al. 1996). To avoid modelling cyclical business dynamics, these scholars recommend using spans of at least five-year time intervals. This is what we have done in this study, and it could account for the contrast in the findings. It is also worth pointing out that many of the existing empirical works on SSA focus on a sample of highly resource-dependent countries (see Tiba & Frikha, 2020; Henry, 2019; Zallé, 2019; Eregha & Mesagan, 2016), implying that they potentially suffer from selection bias problems as they, a priori, favour a finding of resource curse.

Third, and more importantly, in addition to early works using cross-sectional data (e.g., Gylfason, 2001; Sachs & Warmer, 1995), a number of subsequent studies on SSA specify static panel data models that do not account for the dynamic structure of the growth process and employ standard fixed and random effect estimation methods that do not account for the endogeneity of explanatory variables and their correlation with country-specific variables (Ofori and Grechyna, 2021; Eregha and Mesagan, 2016; Anyanwu & Erhijakpor, 2014). Where dynamic panel data models are specified (e.g. Tiba & Frikha, 2020; Henry, 2019; Zallé,

[29]Singer and Caves (2017) point out that in his New York Times best seller, "Thinking Fast and Slow", Nobel Prize laureate Daniel Kahneman explained that "the party in litigation proffering a regression model to a jury was bound to lose. The reason is that regression runs counter to the way we think: Our brains tend to overcompensate when we learn a random fact about a person or thing". One condition for the regression to be a good tool for prediction, they show, is that the regression does not suffer from so-called omitted variable bias.

2019), the small size of the time series (T) does not warrant the widely used estimation methods, such as pooled mean group (PMG), feasible modified OLS (FMOLS) and dynamic OLS (DOLS). These methods require hard-to-satisfy assumptions regarding the properties of the regressors in small-size (T) samples to guarantee consistency of the estimates and validity of the inference (Pesaran et al. 1999; Pedroni, 2001). For example, Pedroni (2001) shows that the FMOLS estimator raises serious concerns with respect to the small sample properties of the associated t-statistic and the possibility of large-size distortions.

A remarkably surprising finding in this PhD study is the result suggesting that complex capabilities embedded in productive structures have a robustly positive and significant effect on long-term growth in developing countries as a whole, but a negative effect in SSA, albeit not significant. This finding underlines a fundamental difference between SSA and the rest of the developing countries with respect to the factors driving their long-term growth dynamics; it may logically account for the historical short duration of growth acceleration periods in SSA compared to the rest of the world (Arizala et al. 2017). The analysis conducted in this study indicates that the average economic complexity level of SSA countries over the 1996-2018 period was significantly lower than that of developing countries as a whole. The majority of SSA countries are positioned in the bottom quartile of the competitiveness ranking in terms of the productive capabilities available in their economic systems. In most countries, especially large resource-rich economies, the capabilities endowment remain smal and less complex, showing no significant patterns of accumulation and upgrading over time and suggesting the presence of a quiescence trap. As a result, many sub-Saharan countries remain concentrated in the chaotic zone of the GDP-Fitness plane, where growth is driven by exogenous forces and not by economic complexity (Cristelli, Tacchella, and Pietronero, 2015). Contrary to the mainstream economic prediction, these countries will not grow faster despite their initial low level of income, consistent with the findings in Cristelli; Tacchella and Pietronero (2015).

The findings from the nonparametric analysis in the Fitness-GDP unveiled fundamental differences between resource-rich and resource-poor economies. Unlike previous empirical works on resource curse, which focus on the coefficients associated with natural resources and other determinants in a growth regression, we quantified the complexity of the productive knowledge and capabilities available in individual SSA countries. We ranked these countries according to their relative global competitiveness, as measured by economic fitness metrics. Surprisingly, Madagascar ranks at the top in SSA., As might be expected, most resource-rich economies rank at the bottom. Except for South Africa and a handful of resource-poor countries, most resource-rich economies remain in the chaotic zone of the GDP-fitness plane, with erratic growth dynamics and low growth potential for transitioning into more sustained and predictable growth regime. We argue that these differences in the complexity of capabilities, growth potential, and dynamics are what drive divergence in economic growth trajectories between resource-poor and resource-rich economies. What is at stake is the effectiveness of capability accumulation processes in place and the policies implemented at firm, industry and country levels to support these processes. As emphasised in recent research reports (Lee. 2019; Lee et all., 2021, Cicera & Malony, 2017), in many developing countries, such as those in SSA, the process of technological capability accumulation and development has failed or remains ineffective. The Schumpeterian gains from technological catch-up remain unrealized in these countries due to underinvestment in innovation activities and the inability of policies to redress this innovation underperformance. This clearly supports the evidence of a quiescence trap found in this study, whereby capability accumulation is path-dependent in the majority of SSA countries.

Our ranking of SSA countries according to the capabilities embodied in their productive structures is different from the Harvard Atlas of Economic Complexity ranking, which uses the ECI. As shown in the literature reviewed in this study, by the nature of its computation, ECI does not account for the diversity of the products, and it leads to an unrealistic ranking of countries (Tacchella et al., 2012; Gabrielli et al., 2017). Our ranking is also slightly different from other rankings that use traditional economic fitness, which is based on exports of goods data only (e.g., Pietronero fitness ranking, World Bank economic fitness ranking). The economic fitness scores used in our study were computed using a so-called "universal Mcp matrix" (Stojkoski et 2016; Zaccaria, Mishra, & Cader, 2018) derived from a novel integrated database, which comprises 97 physical goods sectors and 24 services sectors.

Our findings from the analysis of productive structures and patterns of specialisation complete and enrich the existing body of evidence, which suggests that growth-enhancing structural transformation has accompanied the growth acceleration that many SSA countries enjoyed from the mid-1990s (Diao, Harttgen, & McMillan, 2017; Diao, McMillan, & Rodrik, 2019; McMillan & Harttgen, 2014; McMillan, Rodrik, & Verduzco-Gallo, 2014). These studies focus on sectoral productivity analysis based mostly on the Groningen Africa Sector Database, which covers only 11 SSA countries (18 since 2021) and 10 sectors. Our study relied on the integrated dataset on world trade exports, which comprises 121 sectors (physical goods and services) covering 160 countries, of which 43 are from SSA. The use of trade data to measure structural transformation is justified not only for reasons of data availability, homogeneity, and quality, but more importantly, it has been shown that export data mirrors remarkably well domestic production (Saltarelli et al. 2020; Tacchella et al. 2018). Another justification is based on the key role that structural change exports are assumed to play in catching-up processes (Fagerberg & Verspagen, 2021).

For the first time, using the metrics of economic complexity and looking at their dynamics over a 23-year period from 1996-2018, we comprehensively identified SSA countries that have undergone various degrees of structural transformation. These comprise about 26 out of 43 countries for which data is available. We note that, except for Nigeria, this group includes countries identified in Diao et al. (2019) as exhibiting strong structural change but negative productivity growth in the non-agricultural sector (Ethiopia, Malawi, Rwanda, Senegal, and Tanzania) and those with weak structural change (Ghana, Kenya, Nigeria, and South Africa). The remainder of the 17 SSA countries in our study either have experienced no noticeable structural transformation (Burkina Faso, Guinea Bissau, Seychelles) or have undergone growth-reducing structural change, losing diversity and/or complexity of their productive structures (more remarkable in the case of DR Congo, Cabo Verde, Eritrea, and Zimbabwe).

Our findings from the analysis of the time evolution of the complexity outlook index support the concerns raised in the literature on structural transformation in Africa about the bleak prospects of sustained growth, due mainly to the patterns of structural transformation (Diao, McMillan, & Rodrik, 2019; Diao, Mia, McMillan, & Rodrik, 2021; McMillan & Zeufack, 2022). Most countries, particularly resource-rich economies, are endowed with productive capabilities that position them on the periphery of the product progression network, producing and exporting goods and services in low-complexity sectors such as commodities and resource-based products. Further, and interestingly, not all the 26 countries identified as having undergone structural change have also opened up new diversification paths for upgrading into more complex sectors. Only about 18 countries seem to have managed to progressively accumulate new complementary capabilities and exhibit patterns of specialisation towards the dense areas of the product network where higher-complexity sectors associated with high productivity are located. Unlike in Diao et al. (2019), our results indicate that Ethiopia and

Tanzania have diversified their economies but do not appear to have upgraded into the production of goods and services in high-complexity sectors.

Finally, the analysis of relative industrial competitiveness based on fitness metrics decomposition at sectoral levels provided interesting insights on what some scholars view as a premature deindustrialization in Africa (Rodrik, 2016). The industrial structures of SSA countries, mostly in resource-rich economies, are characterised by both extremely high specialisation in a few low- and medium-complexity sectors and a substantial loss of industrial competitiveness over time. However, in a few resource-poor economies labelled as "improved and established growth performers" (figure 1.2), industrial structures are progressively developing across medium- and high-complexity sectors, albeit with yet lower median competitiveness levels, following the footprints of China and Vietnam. This suggests that these countries have managed to develop policies and programmes to support effective processes for productive capability accumulation and upgrading to accelerate their technological catch-up and sustain their growth. In this regard, the findings of this study are in congruence with the growing body of evidence from the Schumpeterian technological catch-up that have shown that the patterns and rates of long-term economic growth are strongly driven by technological upgrading and innovation (Lee et al. 2021, Mohnen & Hall, 2013, Nelson & Winter, 1982).

Overall, the findings of this study support the predictions of the economic complexity theory of growth and highlight the role of building productive capabilities at all levels (firm, sector, and country) for successful economic diversification and sustained growth. Countries that underwent structural transformation and are enjoying sustained growth appear to have upgraded their capabilities to the ones needed for the production and export of products in complex sectors. They are the ones that have geared their specialisation patterns towards the production of products that are technology intensive. In other words, they are the ones that have adopted advanced technologies, improved management, and organisational practises required to remain competitive in different industrial sectors. Conversely, countries that failed to upgrade their capabilities and innovate are those that are falling behind or remain stuck. The failure or ineffectiveness of underlying capability accumulation processes is a crucial distinction between countries that successfully remain on a sustained growth trajectory and those that fall behind or are stuck.

The findings of this study have significant theoretical and practical implications for research on the determinants of sustained growth in developing countries. First, from a theoretical and empirical standpoint, the results of this study have confirmed that complex capabilities embedded in a country's productive structure are a robust driver of growth in developing countries. In countries with capabilities level under a certain threshold, as is the case in most countries in the SSA, growth is not driven by economic complexity. For these countries, growth accelerations cannot be sustained for a long period unless they are supported by a strong dynamic of capability development and accumulation for technological upgrading, improved business models, and organisational practises.

Moreover, as the results of the growth dynamics in the GDP-Fitness plane revealed, this study confirms the heterogeneous dynamics of the relationship between economic complexity and growth, which is fundamentally dynamic and non-linear, with effects varying according to the growth regime or development phase in which different countries find themselves. In these heterogeneous and dynamic systems, a linear regression-based approach may not be appropriate as it averages interactions and assumes a homogeneous response of growth to its explanatory variables. While the application of estimation methods for heterogeneous panels may be a route in such scenarios, the small-time dimension (T) of the panel datasets available often limits their informed use in the context of growth analysis. This point is often overlooked in resource curse empirical literature, where the use of methods such as PMG and FMOLS may lead to inconsistent estimates and false inferences. Non-parametric analysis, based on economic complexity methods that use dimensionality reduction techniques, is most adequate when analysing economic systems that are inherently heterogeneous and dynamic.

8.2. DEVELOPMENT POLICY IMPLICATIONS

The findings of this study have profound policy implications for sustaining growth in both resource-rich and resource-poor economies. What most constrains economic diversification and sustained growth in sub-Saharan countries is the limited and less complex productive knowledge and capabilities embedded in their economic systems. Consistent with evidence from research papers focusing on technological capability and innovation, the process of productive capability upgrading has failed or remains ineffective in many SSA countries, due to underinvestment in innovation activities, a lack of complementary investments, and market failures (Lee. 2019; Lee et all., 2021; Cicera & Malony, 2017). This calls for a dynamic capabilities approach to economic development that assigns a central role in economic growth to firms, as the locus and ultimate carriers of capabilities, but also an important role to governments in supporting capability accumulation processes (Aistleitner et al., 2021; Nelson, 2008; Sainsbuy, 202; Teece, 2017).

A dynamic capabilities approach contrasts with the conventional macroeconomic approach of neoclassical inspiration theories of growth, which excessively emphasise the accumulation of few aggregate factors and focus on maintaining macro stability under the banner of ensuring “sound macro fundamentals.” It acknowledges that: ‘[T]he proximate cause [of differences in the wealth of nations] lies, for the most part, in the capabilities of firms” (Sutton, 2012, p. 8); it focuses on understanding how individual firms build and manage capabilities, calling for the government to develop and support processes that facilitate entrepreneurship, learning, and innovation. Indeed, as argued by Sainsbury (2020) in his paper “Toward a dynamic capability theory of economic growth”, the growth performance of a country’s economy is critically dependent on two conditions: (i) whether its firms can develop the capabilities to generate and take advantage of “windows of opportunity” that exist for innovation and new markets; and (ii) whether firms are successful in enhancing their capabilities over time to move into higher value-added or complex activities. This resonates with the assimilation theory literature used to explain the growth miracle of the Asian tigers by Nelson and Pack (Citation1999, p. 434) who state that ‘if … one marshals [inputs] but does not innovate and learn, development does not follow’.

While scholars in recent years have drawn insights from the relatedness framework used in this study to identify promising diversification paths and inform industrial policy design, especially in regional development policy frameworks (Balland et al., 2019; Hidalgo, 2022), the dynamic capabilities approach emphasises the need for industrial and innovation policies to reduce path-dependencies in the capability accumulation processes. Such path-dependencies result in lock-in into a quiescence trap where initial capability endowment is low and constrain countries to remain specialised in low-complexity sectors that are nearby the capabilities they currently possess. Without new incentives and support for capability development, SSA countries that are unable to innovate in the industries in which they are currently specialised will unlikely be able to do so in new industries.

More concretely, due to multiple market and system failures in developing economies that are widely documented, particularly in SSA, it is time for policymakers to place innovation policy at the centre of their strategies to support the development of capabilities that are critical for firms to adopt advanced technologies and realise the full returns of innovation-related investments. This goes beyond a simple provision of R&D and should cover essential dimensions along the areas of constraints to innovation-related investment and technological adoption. These dimensions include, among others: (i) the critical complements to innovation investment needed to realise their high potential returns; (ii) the range of firm capabilities required to undertake innovation and take it to market; and (iii) the required government capabilities for designing and implementing effective innovation policies (Cicera & Malony, 2017).

With regard to the first dimension, policymakers in SSA countries should aim at removing the underlying conditions that often impede the development of a broad set of complementarities, such as the accumulation of physical and human capital, infrastructure efficiency, energy availability, regulations, etc., as well as those seen as particular to innovation, such as intellectual property rights protection or market failures that disincentivize the accumulation of knowledge. Unless policymakers include actions to improve on these broader complementary factors and support institutions in their National Innovation Systems (NIS) policies, firms will find it less attractive to invest in innovation and build capabilities to diversify and upgrade into higher-complexity sectors. The overall result will be a loss of industrial competitiveness, as the data analysed in the study suggested.

The second dimension which innovation policy should covers in SSA countries focuses on supporting the development of firm's capabilities, including technological, managerial, and organisational practices that are critically missing in developing country firms30. Cicera & Maloney (2017) point to the large body of literature in the NIS tradition which argues that, to innovate and manage innovation projects effectively, firms need to acquire a range of capabilities. This literature stresses the acquisition of these capabilities as fundamental to both

[30] Citing the World Management Surveys (WMS), Cicera & Maloney (2017)) note that developing country firms are indeed lagging in a wide range of capabilities that are critical to the Schumpeterian catch-up process. Average scores in monitoring, employment of just-in- time processes, internal feedback mechanisms, long-run planning and goal stretching, and human resource policies in poor country firms are well below those in frontier countries.

productivity and quality upgrading (citing Teece & Pisano, 1994); Sutton, 2012; Sutton & Trefler, 2016; Hallak, 200)). Development of firms 'capabilities can be achieved through a combination of industrial innovation policies and programmes that support learning processes (Gao, 2021; Pietrobelli, 2021; Cicera et al. 2020). These include: (i) implementation of large-scale programmes to help development of technological capabilities; (ii) promoting participation in international trade through exports, with the aim to provide incentives to upgrade and expose firms to new ideas, increase access to technology and its embedded know-how, learn about more sophisticated and contested markets; (iii) attracting foreign direct investment (FDI) that can provide important learning opportunities, invest in R&D and introduce product innovations; (iv) implementation of global value chain (GVC)-oriented policies that facilitate exposure to multinational enterprises (MNEs) and participation in GVCs as sources of knowledge spill overs.

The third dimension of policy action for developing capabilities in SSA countries calls for increased attention to more evidence and rigour in the design and implementation of industrial innovation policy. Given that the necessary policy capabilities to diagnose problems, identify policy solutions, and implement them are very weak in the context of these countries (Cicera & Malony, 2017), this dilemma must be confronted to minimise the risk of failure by implementing solutions that support the capacity building of governments in a number of areas, including: (i) getting the mix of policies right by a choice of instruments that are more appropriate based on the stage of development of the innovation capabilities of firms and the implementation capabilities of governments: the capabilities escalator (Cirera and Maloney 2017). (ii) investing in government capabilities through better processes and institutions; and (iii) addressing the information gap with respect to the range of instruments available to address a specific innovation problem and the institutional capacity and market conditions required to implement policies successfully. Cicera et al. (2020) offer a Practitioner's Guide to Innovation Policy, which provides a rigorous typology of innovation policy instruments, including evidence of impact—and more importantly, the critical conditions in terms of institutional capabilities to successfully implement these policy instruments in developing countries.

Other important dimensions of industrial innovation policy will be relevant, depending on the development stage of each SSA country. Most low-income countries in SSA should focus on supporting capabilities for the adoption of existing advanced technologies needed to shift their specialisation patterns from commodities and resource-based manufactures to technology-based products in medium-to-high-complexity sectors. Countries that are stuck in the middle-income trap should address transition upgrading failure, which refers to difficulties facing middle-income countries in their efforts to make a transition from imitation/implementation to innovation/design stage of technological capability upgrading (Lee, 2019; Lee et al. 2021). For upper middle-income countries in SSA, such as Mauritius, Namibia, and South Africa, unless they succeed in deepening and diversifying the industrial structure and technological knowledge through transition to design capabilities and/or leapfrogging strategies, their transition to high-income status will be hampered. Governments in these countries should restructure their innovation systems around the concept of design capabilities.

While industrial policy is no longer despised by mainstream economics, but has obtained a new burst of life, a word of caution might be needed here in light of the unexpected effects documented by studies, which show that it is not simply growth but also a particular form of ecologically sensitive growth that an evolutionary theory of African economies guides/helps to understand and shape (e.g., Obeng-Odoom 2014; Obeng-Odoom, 2022; Obeng-Odoom, 2023). For example, in Obeng-Odoom (2023), it is argued that "industrial policy has been too strictly tied to (urban) economic growth which has not, contrary to expectations, led to ecologically sensitive and inclusive (urban) economic development"(Abstract). For this scholar, industrial growth policies have cumulatively generated rising urban inequalities and ecological problems in cities and regions. He stresses that " a different industrial policy that could recoup socially created, but privately appropriated, unearned income, is needed" (p.158). He pointed out that " such a policy would need to guide the reinvestment of the resulting income in ways that would enhance state capacity, address persistent inequalities and social stratification, and create industries that would avoid the problems (p. 158).

8.3. SUMMARY CONCLUSION

We have focused in this Ph.D. study on investigating the respective roles of natural resources and countries' productive capabilities, with the aim of unravelling the long-term growth dynamics and potential to sustain rapid growth across sub-Saharan countries. We used both the regression-based approach, and the nonparametric methods grounded in complex network theory. We close this study by reiterating what we think are the three key findings that come out of our research. First, the main obstacle to sustained rapid growth in sub-Saharan economies is not the resource curse but rather the limited incentives to develop complex productive capabilities – a phenomenon referred to as a quiescence trap. There is no evidence supporting the hypothesis of a natural resource curse in SSA during the unprecedented growth acceleration period that many countries in this region experienced from the mid-1990s. Natural resource dependence did not play a significant role, if at all negative, in driving cross-country growth differences in SSA. Capabilities embedded in the economic systems of sub-Saharan countries negatively affect long-term growth dynamics, albeit not significantly. The long-term growth dynamics in this region tend to be different from the rest of developing countries, where we find overwhelming evidence of robustly positive long-term growth effects of natural resources and complex productive structures.

The second key finding is that SSA is home to economies embedded with a small and less complex productive capabilities, inhibiting their potential for sustained growth relative to economies in other regions of the world. In this regard, we emphasised significant variations between resource-rich and resource-poor countries. The world competitiveness ranking of economies, based on an individual country's economic fitness score, indicates that 75 percent of sub-Saharan countries position in the bottom quartile. Except for South Africa, the SSA economies that appear first in the ranking are those in resource-poor economies. Most surprisingly, Madagascar is at the top over the entire period, while most resource-rich economies, including Angola, Nigeria, and the DR Congo, rank among the last at the bottom. Except for a few resource-poor economies and South Africa that have transitioned into the development phase where growth dynamics are driven by complex capabilities, most sub-Saharan economies are stuck in a poverty trap regime, due to their small and less complex endowment of productive capabilities. The patterns of their growth dynamics exhibit erratic behaviour, slowing down economic convergence.

Finally, the third key finding is that the majority of SSA countries (but not resource-rich economies only) are highly specialised in the production of goods and services in a few low-complexity sectors which are associated with lower productivity. Their patterns of specialisation display less dynamics towards the medium- to high-complexity sectors positioned in the core centre or dense areas of the product network. This implies that these countries have fewer paths to economic diversification and industrial upgrading. Sub-Saharan countries categorised as "improved and established growth performers," mostly resource-poor economies, tend to be those that have initiated strong dynamics of complex capability development and upgraded into medium-complexity sector. Thus rapid sustained growth is associated with improved relative competitiveness at both country and industrial sector levels.

This PhD research contributes, in significant ways, to the scholarly literature on growth performance in resource-rich and resource-poor economies. First, this study used evolutionary econometrics and contributes to the empirical literature on Schumpeterian-based endogenous growth models, which emphasise technological learning and innovation as being at the core of the growth process. It did so by focusing on the role of capabilities accumulation and upgrading. Using economic complexity methods, we quantified the complexity of the capabilities embedded in a country's productive structure and then used the derived metrics as a potential determinant of growth. By doing so, we not only revive the idea intuitively behind the Schumpeterian-based endogenous growth models, but more importantly, we reduce the potential omitted variable bias inherent in any growth regression model that ignores the role of country's productive structure complexity. The extended growth regression model allows us to go beyond the resource curse and to evaluate the presence of other growth and development traps that would otherwise be taken erroneously as evidence of resource curse.

Second, this PhD has contributed to the literature on evolutionary theory of growth by emphasising the heterogenous nature of the growth process and the role of economic complexity in constraining or enabling transition into different growth regimes as countries go through different development phases. The neglect of these key aspects by mainstream growth researchers has led to what some scholars view as " wrong economics" in the context of growth in Africa (See Jerven,2014; Obeng-Odoom F, 2017). By combining economic complexity metrics (a non-monetary measure of intangible assets) with monetary measures such as the gross domestic products (GDP), this PhD study uses a non-parametric approach based on the tools of dynamical system theory to analyse the growth potential and economic dynamics of individual resource-poor and resource-rich countries. By adopting the evolutionary approach, we identify different growth regimes and the changing interactions between EC, the other relevant growth determinants, and economic growth, which is useful for understanding why similar improvements in chosen growth fundamentals may lead to unexpected outcome on economic convergence and the dynamic of growth in different countries. We provided evidence supporting previous works in economic complexity which show that there is no advantage in terms of faster growth and convergence for countries with initial low income unless their economic complexity is beyond a certain threshold.

Lastly but not the least, this PhD study has contributed to the empirical literature on structural transformation in Africa. Building on insights from complex network theory, we applied metrics of economic complexity and relatedness in the product space to analyse structural transformation. These metrics were computed from a novel integrated dataset of countries' exports, which captures the sophistication of industrial sector at a more disaggregated fine-grained data level and covers virtually all SSA countries. Such analysis underlines the capacity of countries to accumulate and upgrade their productive capabilities as being the forces driving the speed and patterns of structural transformation, as well as their industrial competitiveness.

The findings from this study are consistent with the recent evidence from growth research using the Schumpeterian technological catch-up and innovation framework, which emphasises the upgrading of technology capabilities as the major reason for the rapid growth of the catch-up economies, in particular East Asian emerging economies. Therefore, it advocates for a change of policy paradigm to focus on industrial and innovation policies, targeting productive capabilities at firm, industry, and country levels. We argue that, unless SSA countries design and implement effective policies and programmes that support capability accumulation and upgrading, growth will not be sustained. This is completely different from the orthodox policies that are implied in the empirical literature on resource curses and growth turning points, which emphasise the importance of ensuring sound macroeconomic fundamentals and completing institutional reforms. In the current era of technological revolution—featured by digitalization, robotics, machine learning, and artificial intelligence—that offers many opportunities for technological upgrading, macroeconomic stability and endless institutional reforms will not suffice to accelerate and sustain growth.

This PhD study opens several areas for further work. First is the empirical question of whether long-term growth responds homogeneously or not to changes in productive structures regardless of the growth phases in which different countries find themselves. The estimation method imposed by the structure of our dataset (a panel with large N but small T) could not allow the estimation of heterogeneous effects for different countries. As panel data with a large time dimension becomes available, further research could use estimation methods for heterogeneous panel data, such as PMG and FMOLS, to comprehensively inform on the long-term effect of a country's productive capabilities – distinguishing countries that have sustained growth from those that have not - and using the empirical framework developed in the literature on growth turning points.

Second, while we have used metrics of economic complexity and relatedness to analyse how the individual countries ' productive structures evolve over time, it would be interesting to undertake case studies in order to explore how some countries have succeeded in rapidly accumulating productive capabilities and upgrading into relatively medium- to high-complexity sectors. What incentives were put in place to stimulate investment in innovation activities? What processes were effectively supported to facilitate the accumulation of capabilities and their upgrading at firm, industry, and country levels? What are the capabilities of government agencies and institutions to accurately diagnose and articulate the problem that is constraining innovation and subsequently design and implement more effective policies and programmes?

Third, it is well documented that natural resource abundance/dependence are negatively associated with complex capability accumulation, that is, countries with abundant natural resources or depending on them possess a low and less diversified endowment of capabilities. However, the transmission mechanisms between natural resources and productive capabilities are not clear. Given the recent evidence indicating that there is a significantly positive relationship between economic complexity on the one hand and human capital, institutions, investment in technology, and trade openness on the other, it would be interesting to explore whether there is an overlap of resource curse with quiescence trap through the effect of natural resources on these variables. Does natural resource abundance/dependence adversely affect productive capability accumulation and upgrading through its effect on human capital, financial intermediary development, and institutional quality? These and other related questions deserve further research to complement the findings of this PhD study and better inform effective policy design for sustaining growth in sub-Saharan Africa.

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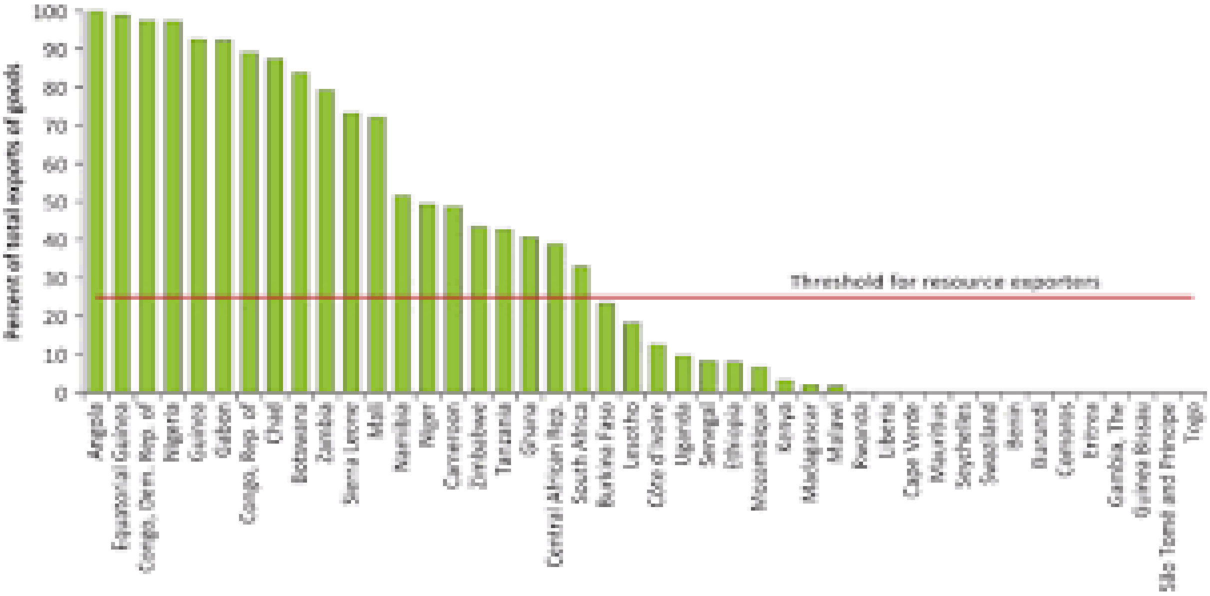
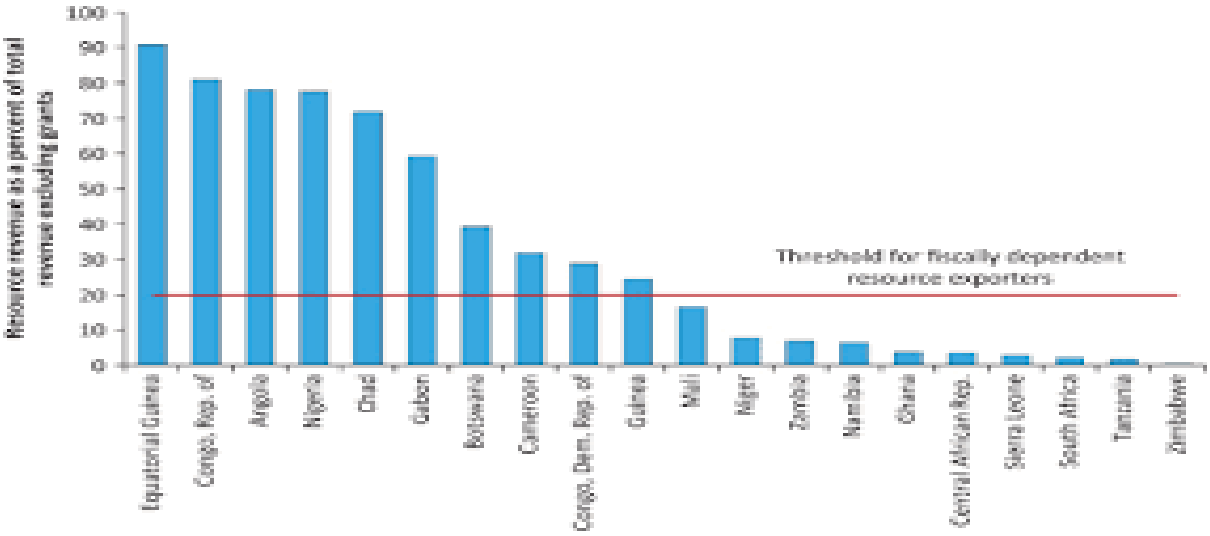
APPENDIX A: SUB-SAHARAN RESOURCE-RICH AND RESOURCE-POOR COUNTRIES

PANEL A. Sub-Saharan Africa: Resource Exports, Average 2005–10



PANEL B: SSA Resource-Rich Countries: Resource Revenue, Average 2005–10



Source: IMF (2013). Regional Outlook for Sub-Saharan Africa: Boom, Bust, or Prosperity? Managing Sub-Saharan Africa's Natural Resource Wealth. Notes: Resource-rich are those countries with exports of mineral resources (oil, gas, mineral) equal or exceeding 25 percent of total exports.

APPENDIX B: Medium- Term Economic Forecast for SSA

Economic Forecasts: Sub-Saharan Africa

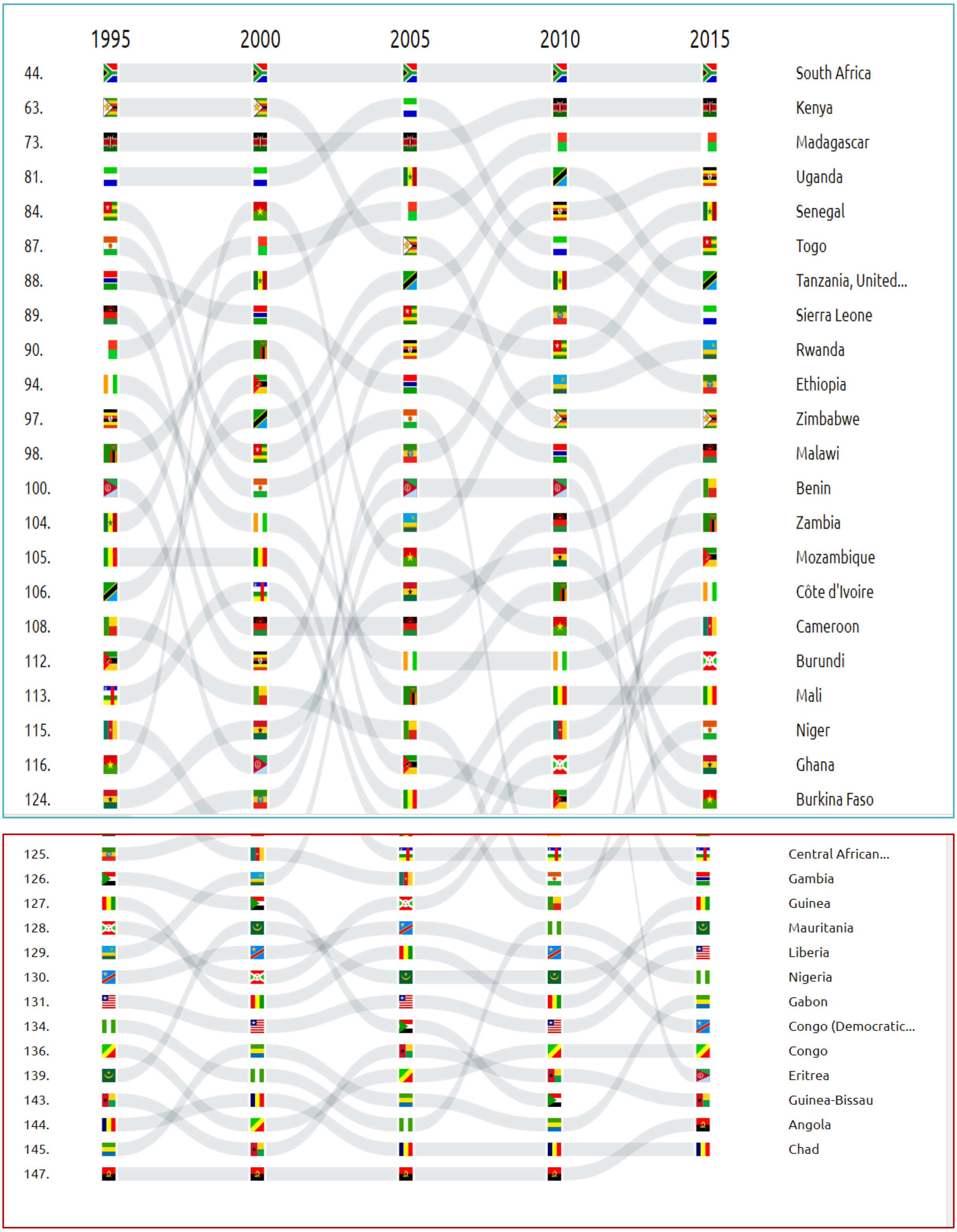
(Real GDP growth; percent)

		PROJECTIONS	
	2022	2023	2024
Sub-Saharan Africa	**4.0**	**3.3**	**4.0**
Angola	3.0	1.3	3.3
Benin	6.3	5.5	6.3
Botswana	5.8	3.8	4.1
Burkina Faso	1.5	4.4	6.4
Burundi	1.8	3.3	6.0
Cabo Verde	17.0	4.4	4.5
Cameroon	3.8	4.0	4.2
Central African Republic	0.5	1.0	2.5
Chad	3.4	4.0	3.7
Comoros	2.6	3.0	3.5
Congo, Democratic Republic of the	8.9	6.7	4.7
Congo, Republic of	1.7	4.0	4.4
Côte d'Ivoire	6.7	6.2	6.6
Equatorial Guinea	3.2	-6.2	-5.5
Eritrea	...	...	...
Eswatini	3.6	3.1	3.3
Ethiopia	6.4	6.1	6.2
Gabon	3.0	2.8	2.6
The Gambia	4.9	5.6	6.2
Ghana	3.1	1.2	2.7
Guinea	4.3	5.9	5.6
Guinea-Bissau	4.2	4.5	5.0
Kenya	4.8	5.0	5.3
Lesotho	2.1	2.1	2.3
Liberia	4.8	4.6	5.3
Madagascar	4.0	4.0	4.8
Malawi	0.8	1.7	3.3
Mali	3.7	4.5	4.8
Mauritius	8.7	5.1	3.8
Mozambique	4.2	7.0	5.0
Namibia	4.6	2.8	2.7
Niger	11.9	4.1	11.1
Nigeria	3.3	2.9	3.1
Rwanda	8.2	6.2	7.0
São Tomé & Príncipe	0.1	0.5	2.4
Senegal	4.0	4.1	8.8
Seychelles	8.9	4.2	3.9
Sierra Leone	4.0	2.7	4.7
South Africa	1.9	0.9	1.8
South Sudan	0.5	3.5	4.2
Tanzania	4.7	5.2	6.1
Togo	5.8	5.4	5.3
Uganda	6.4	4.6	5.7
Zambia	4.7	3.6	4.3
Zimbabwe	6.2	4.1	3.6

Source: IMF World Economic Outlook Database, October 2023.
Note: Data for Eritrea are excluded due to constraints in data reporting.

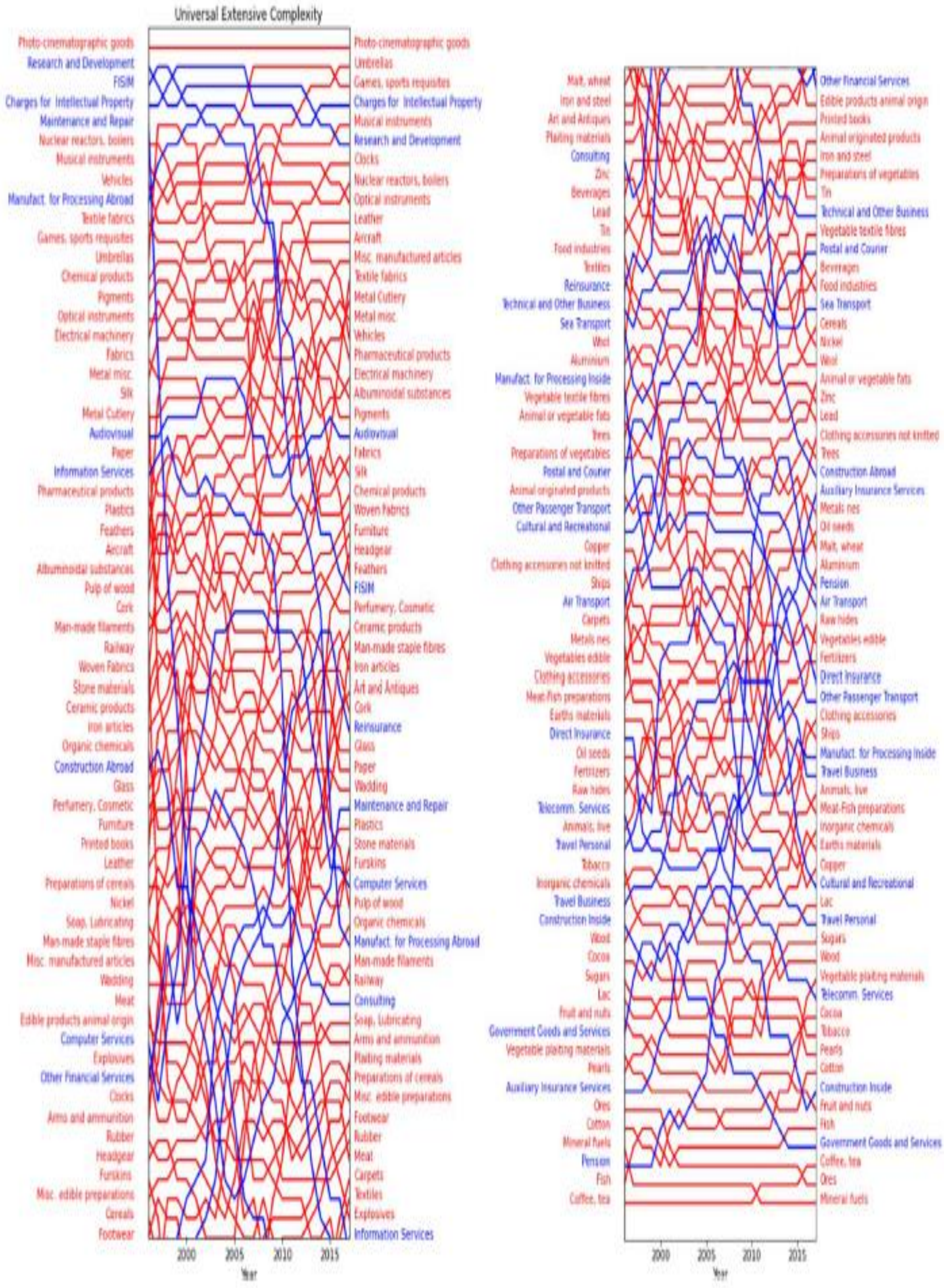
IMF

APPENDIX C. SUB-SAHARAN COUNTRIES ECONOMIC FITNESS RANKING



Source: Luciano Pietronero International Country Fitness Ranking : https://www.economic-fitness.com/en/international-economic-fitness-ranking

APPENDIX D: SECTORS COMPLEXITY RANKING



***The series of the complexity ranking of the Integrated Sectors**.Notes: The red colours refer to the physical Goods while the blue colours indicate the Services. Source: Patelli et al. (2022). Integrated database for economic complexity. Scientific Data, 9(1), 628.*

APPENDIX E: DEFINITION OF VARIABLES AND SOURCES OF DATA

Variables	Source	Definition/Description
GDP per capita (PPP)	International Comparison Program, World Bank | World Development Indicators database, World Bank	GDP per capita, PPP (constant 2017 international $). GDP per capita based on purchasing power parity (PPP). PPP GDP is gross domestic product converted to international dollars using purchasing power parity rates
Total natural resource rents (% of GDP)	World Bank | World Development Indicators database, World Bank	Total natural resources rents are the sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents, and forest rents.
Economic fitness	Enrico Fermi Research Centre | Integrated database for economic complexity. Public repository accessible at https://efcdata.cref.it	Economic Fitness Scores of countries computed using Economic Fitness Complexity (EFC) algorithm (Tacchella et al. 2012) based on universal dataset. This dataset is derived by implementing machine learning techniques to reconstruct the export flow of services (from IMF) and then combine them to the export flow of the physical goods from COMTRADE (see Patelli et al. 2021 for methodology).
Economic complexity index	Enrico Fermi Research Centre Integrated database for economic complexity. Public repository available at https://efcdata.cref.it	Economic complexity index of countries computed using the method of reflections (MR) (Hidalgo & Hausman, 2009) based on universal dataset.
Complexity outlook index	Enrico Fermi Research Centre Integrated database for economic complexity. Public repository available at https://efcdata.cref.it	Economic complexity outlook index of countries computed using the method of reflection (idalgo & Hausmann) as extended in Hausman et al. (2014) based universal dataset.
Investment (share of GDP)	Penn World Tables (PWT 10) (cash_ i)	Share of gross capital formation at current PPPs
Human capital index	Penn World Tables 9.0 (PWT 10) (hc)	Human capital index, based on years of schooling and returns to education
Life expectancy	World Bank | World Development Indicators database, World Bank	(Life expectancy at birth, total)
Employment rate	Penn World Tables 9.0 (PWT 10) (emp/pop)	Employment ratio (employment in millions, population in millions).

Financial development index	IMF Data | Financial Development Index Database | International Monetary Fund	Overall index of financial development derived by aggregating nine indices that summarize how developed financial institutions and financial markets are in terms of their depth, access, and efficiency.
Trade openness	Penn World Tables (PWT 10) Share of merchandise exports at current PPPs (csh_x) Share of merchandise imports at current PPPs (csh_m).	Trade openness defined as the ratio of exports plus imports over GDP.
Political stability	World Governance Indicators | World Development Indicators database, World Bank	Political stability and absence of violence/terrorism – "capturing perceptions of the likelihood that the government will be destabilized or overthrown by unconstitutional or violent means including politically motivated violence and terrorism" (Kaufmann et al. 2011, p.223)
Control of corruption	World Governance Indicators | World Development Indicators database, World Bank	Control of Corruption – "capturing perceptions of the extent to which public power is exercised. for private gain, including both petty and grand forms of corruption, as well as "capture "of the state by elites and private interests" (Kaufmann et al., 2011, p.223)
Rule of law	World Governance Indicators| World Development Indicators database, World Bank	Rule of Law- "capturing perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence" (Kaufmann et al., 2011, p.223)

APPENDIX F: SUB-SAHARAN AFRICA: RESOURCE CURSE EMPIRICS UPDATE

Authors	Year	Sample period	Countries	Dependent variables	Proxy for natural resources variable	Methods	Main results
Henry	2019	1970-2014	21 SSA countries rich in natural resources	Real GDP per capita	Total natural resources as a rent share of GDP.	Panel data, FMOLS, DOLS , and error correction.	Total natural resources rent significantly decreased economic growth, confirming the phenomenon
Yang et al.	2019	1998-2016	22 SSA countries rich in natural resources	GDP per capita	Per capita natural resource rents.	Panel data, fixed effect with Driscoll-Kraay standard error, instrumental variable two stage least square (IV-2SLS), and GMM-system	Natural resource rents have a significant positive impact on economic growth. Such result contradicts the argument of the resource curse.
Tiba and Frikha	2020	1990-2013	22 African countries	GDP per capita	Resources intensity (average of oil rents, natural gas rents, coal rents, mineral rents, and forest rents).	Panel data, FMOLS and DOLS	Resources intensity adversely affect economic growth, providing strong evidence of the phenomenon.
Ofori and Grechyna	2021	1990-2017	43 SSA countries	GDP per capita growth	Natural resource rents, oil rents, gas rents, and forest rents as a share of GDP.	Panel data, fixed effect, random effect, and GMM.	Natural resource rents, oil rents, and gas rents significantly decreased GDP per capita growth, supporting the phenomenon. In contrast, they found that forest rents significantly enhanced growth of GDP per capita, contradicting it
Anyanwu and Erhijakpor	2014	1975-2005	49 African countries	Democracy	Oil wealth per capita	Panel data, pooled OLS, fixed effect, and IV-2SLS	Panel data, pooled OLS, fixed effect, and IV-2SLS

Asiamah et al.	2022	2005-2019	39 SSA countries	Control of corruption, rule of law, regulatory quality, governance effectiveness, voice and accountability, and political stability.	Total natural resource rents, mineral rents, natural gas rents, coal rents, and oil rents as a share of GDP.	Panel data GMM	All natural resource variables significantly weaken all institutional indicators, which supports the existence of the resource curse.
Eregha and Mesagan	2016	1996-2013	5 oil-rich African countries	GDP per capita growth	Oil exports per capita, net oil exports, and oil production per capita.	Panel data, pooled, fixed, and random effects.	Oil exports per capita have a significant negative effect on economic growth, confirming the oil curse. However, net oil exports and oil production per capita have a significant positive effect, contrasting with the oil curse. All the interaction term variables (oil and institutions) have a significant negative effect on economic growth. This suggests that there is curse via institutions
Zallé	2019	2000-2015	29 SSA countries	GDP per capita growth	Natural resource rents as a share of GDP	Panel data, ARDL	Natural resource rents significantly reduced GDP per capita growth, supporting the phenomenon but this was when the analysis controlled for government stability, corruption, and ethnic tension. However, when the analysis controlled for the risks of internal conflict, religious tension, and democratic freedom, natural resource rents favour GDP per capita growth,

							confirming the natural resource blessing. The outcomes of the interaction effect of natural resource rents with socioeconomic condition, religion tension, ethnic tension, and democracy show a statistically significant negative impact on GDP per capita growth, suggesting that grabber-friendly institutions hinder economic growth to sustain. In contrast, when the analysis interacted the natural resource rents with internal conflict and corruption, both the interaction effect variables are positively and significantly related to higher economic growth. This suggests that producer-friendly institutions alleviate the resource curse problem.
Epo and Nochi Faha	2020	1996-2016	44 African countries	GDP growth	Natural resource rents as a share of GDP and share of ores and metals exports in total merchandise exports.	System dynamic panel data instrumental variables	Their results showed an adverse effect of the natural resource rents on economic growth, confirming the phenomenon. However, the coefficients of the interaction effect of the natural resource rents with control of corruption, rule of law, and voice and accountability are a positive and statistically significant, suggesting that producer-friendly institutions ease the natural resource curse problem

Dwumfour and Ntow-Gyamf	2018	2000-2012	38 African countries	Financial stability and domestic credit to private sector as a share of GDP	Natural resource rents as a share of GDP	Panel data, GMM	Natural resource rents significantly reduced stability of the banking sector, suggesting a resource curse. But they have a significant positive impact on domestic credit. This indicates that resource wealth increases the growth of the banking sector trough the credit channel.
Anyanwu and Erhijakpor	2014	1975-2005	49 African countries	Democracy	Oil wealth per capita	Panel data, pooled OLS, fixed effect, and IV-2SLS	Panel data, pooled OLS, fixed effect, and IV-2SLS