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Sub-Saharan Africa and the 4th Industrial Revolution

Technological Leapfrogging as a Strategy to enhance Economic Growth?

by

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The 4th Industrial Revolution provides a window of opportunity for the developing world and in particular, Sub-Saharan Africa to catch-up in terms of social and economic development by enhancing growth through technological advances. At the same time, it bears the risk for Sub-Saharan Africa to fall even further behind if technological advances cannot be absorbed into the region's economies. Although, media coverage is growing, academic literature on the topic is scarce and no real strategies on how to use the 4th IR to enhance economic growth in SSA are provided. This research uses an adapted qualitative comparative analysis approach and investigates whether SSA countries are well suited to use technological leapfrogging as a strategy to absorb and adapt technological advances of the 4th IR. Additionally, it assesses how these technological advances are translated into sustainable economic growth in SSA. The main approach involves analysing the presence of factors that determined successful technological leapfrogging in the East Asian Miracle economies in SSA. Accounting for the region's heterogeneity, this study finds that the most competitive and advanced countries provide a very good basis for technological leapfrogging, and have already embarked upon a path-creating leapfrogging process. However, the translation of technological leapfrogging into economic growth is hampered by infrastructural problems, even in the most competitive countries. Policy recommendations provided include enhancing the creation of business- and investment-friendly environments in less competitive countries to build a better basis for technological leapfrogging as well as investments promoting interregional projects on improving infrastructure, human capital, governance as well as economic stability throughout the growth process.

Keywords: 4th Industrial Revolution, Sub-Saharan Africa, Economic Growth, East Asian Miracle, Technological Leapfrogging

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List of Abbreviations

1st IR - First Industrial Revolution
2nd IR - Second Industrial Revolution
3rd IR - Third Industrial Revolution
4th IR - Fourth Industrial Revolution
AI - Artificial Intelligence
EAM - East Asian Miracle
EAME - East Asian Miracle Economies
FDI - Foreign Direct Investments
GCI - Global Competitiveness Index
GCR - Global Competitiveness Report
GDP - Gross Domestic Product
IMF - International Monetary Fund
QCA - Qualitative Comparative Analysis
R&D - Research and Development
RTA - Regional Trade Agreement
SME - Small- and Medium-sized enterprises
SSA - Sub-Saharan Africa
UN - United Nations
UNDP - United Nations Development Programme
WEF - World Economic Forum

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1 Introduction

"With the rapid development of the global digital economy and the availability of technology, the next century belongs to Africa"

Ban Ki-moon, Financial Times, 2018

The 4th Industrial Revolution (4th IR) is often referred to as window of opportunity for developing countries, and in particular Sub-Sahara African (SSA) countries, to catch up with the developed world. Especially the rural areas in SSA can benefit from technological advances, as for example shown by new financial services through mobile banking such as M-pesa in Kenya. Moreover, technological change could allow SSA to skip certain development stages as they are not bound by out-aged technologies but the region can rather take the lead in innovation and technologies of the 4th IR, such as drones, robotics, artificial intelligence and renewable energies. These development-enhancing paths relate to the concept of technological leapfrogging (WEF, 2018a).

However, discussion among scholars and investors is emerging on whether the 4th IR represents a window of opportunity for Africa or rather poses the risk of falling even further behind. Founder of the Bill & Melinda Gates Foundation for development Bill Gates, states that although technology has a lot of power to promote economic development in SSA, there are limits to technology for economic development. The political economy, institutions, governance and stability of an economy play a big role for development as well, as technology itself seems to only complement rather than to initiate economic growth processes (Pilling, 2018; Bates Ramirez, 2018). Additionally, literature suggests that sustainable economic development depends on initial conditions in terms of the socio-political structure and technological capabilities of the economy.

Opinions about the potential of the 4th IR for SSA to enhance economic development are generally positive and increasing in number, however being only at the start of this

technological revolution, nobody can be entirely sure about what exactly, when and how it will happen (Financial Times, 2018; KPMG; n.d.; SASDGHub, 2018, Schwab, 2016). Additionally, no specific strategies are provided in the opinions on how SSA can use the 4th IR as window of opportunity and on how SSA can prevent the risk of missing out and falling back further.

This research sets out to fill this gap by analysing a possible strategy for SSA to benefit from the 4th IR, namely technological leapfrogging. The study is motivated by the opportunity for SSA to enhance economic growth sustainably and substantially through technological advances of the 4th IR. By combining several known concepts, such as technological leapfrogging, economic growth and the well-known example of the EAM this research sets out to analyse firstly, the possibility of using leapfrogging in SSA and secondly to formulate policy recommendations to successfully translate the 4th IR into sustainable economic growth in the region.

Ultimately this research poses the following guiding question:

Can Sub-Saharan Africa adapt the strategy of technological leapfrogging to use the 4th Industrial Revolution to enhance economic growth and development?

In order to assess this question, the feasibility of using technological leapfrogging in SSA to benefit from technological advances of the 4th IR is assessed by applying an adapted qualitative comparative analysis (QCA). Factors defined as main drivers for successful technological leapfrogging leading to the East Asian Miracle (EAM) are applied to the case of SSA in order to investigate whether the region provides the necessary basis for technological leapfrogging. Additionally, recent processes in SSA are examined and discussed in light of the foregoing analysis' results in order to analyse how technological leapfrogging in the 4th IR can be translated into sustainable economic growth. This study hypothesizes that most countries have the potential to apply technological leapfrogging. However, social capabilities, initial conditions and accompanying factors such as infrastructural quality need to be accounted for as well, to support, embed and translate technological advances into economic growth.

By doing so, this research contributes to the literature on economic growth in SSA by dealing with the very recent topic of the 4th Industrial Revolution and providing a possible strategy on how to use it to enhance economic development. Additionally, this research uses the prime

example of sustainable economic growth through leapfrogging, the EAM, as basis for its analysis. It adapts the analytical method of 'qualitative comparative analysis' to the case of SSA by using a pre-defined set of important factors, proven to be of substantial importance for successfully applying technological leapfrogging during the EAM (Quibria, 2002; Page, 1994). This makes this study relevant to assess the potential and feasibility of using technological leapfrogging in the context of the 4th IR to enhance economic development in SSA. Adapting the traditional QCA to compare an actual and a potential case rather than comparing two actual cases makes the approach of this research original. Additionally, the studies originality arises from its aim to assess the possibilities of the 4th IR and a potential strategy to use the 4th IR for sustainable development in SSA, which is scarcely covered.

The remainder of this study is structured as follows: section two explains the general framework of the study, including a review of the literature on the topic, the theoretical background of the study and the general analysing method as well as its operationalization. Section three provides the main analysis of this study and outlines this study's results on the feasibility of applying technological leapfrogging in SSA. Additionally, section three discusses the analytical results and puts them into the context of the 4th IR in order to analyse how technological leapfrogging translates into economic growth. Lastly, section four concludes the findings of this work, summarizes policy implication and outlines further research options.

2 Building a Framework

This section sets out to build the framework of this research's analysis by reviewing academic literature concerning the research problem and the theoretical background of the analysis. Additionally it provides the analytical framework, explaining the general methods used and how these are applied to the context of this analysis. Lastly, this section provides information on the data used and its reliability.

2.1 Literature Review

Academic and theoretical literature has shown that technology was and is a key driving force for sustainable economic growth and development. However, while media coverage of the 4th IR and its potential for development in SSA is rising, academic literature on this topic is scarce and appearing only slowly. Furthermore, the media coverage lacks detail about specific strategies on how to use the technological potential arising from the 4th IR in SSA and the feasibility thereof. This research sets out to contribute to this gap in the literature by analysing a possible strategy to use the 4th IR to enhance development in SSA, namely leapfrogging. Leapfrogging has been successfully used by East Asian Miracle Economies (EAME) to leapfrog into manufacturing production processes ahead of the economies' comparative advantage and development level and thereby led to the EAM.

To set the scene for this study's analysis and due to scarcity on the specific topic of the 4th IR and its potential for SSA, it is important to explore the literature surrounding this specific topic. This refers to the 4th IR, general economic development in SSA, and the example of leapfrogging during the EAM. The following section uses these strands of literature to lay down the basics of the topics surrounding the research problem concerning the lessons that could be learned from EAME to use the 4th IR for development upsurges in SSA.

The 4th Industrial Revolution

The body of literature concerning the 4th IR is growing rapidly in relation to the technological advancements, how it will spread, what to expect and how developed countries in particular as well as how businesses in these economies need to adjust. The concept of the 4th IR is most profoundly developed and explained by Klaus Schwab (2016). He argues that the fourth wave of the industrial revolution will spread faster, diffuse wider and interrupt heavier than the prior three waves. He mentions that the 4th IR is evidence against the secular stagnation theory initiated by Hansen (1939) and recently re-emphasized by Summers (2014), Krugman (2014) and Gordon (2012) of long-term economic stagnation and low to negative GDP growth rates, as the immense positive impact of the 4th IR on productivity and growth will be felt soon (Schwab, 2016).

The 1st IR referred to the technological advances of the steam engine, building of railroads and the general mechanization of production between 1760 and 1840 and is argued to be the starting point of modern economic growth as it altered the society significantly (Engels, 1845). This was followed by the 2nd IR, which introduced mass production in the late 19th to early 20th century (Landes, 2003; Mokyr, 1998). The 3rd IR, also referred to as the computer and digital revolution, started in the 1960s and introduced general computing and the internet (Debjani, 2014). Schwab argues that although the 4th wave builds up on the technology introduced during the 3rd wave, the current wave will be more disrupting in its technological as well as global impact. The 4th wave yields possibilities for developed and developing countries to participate by transforming societies and economies around the globe (Schwab, 2016). This clearly differentiates its impact from the 2nd and 3rd wave. The 2nd IR has not been fully experienced by around 17% of the global population, which still lack electricity access and half of the global population does not enjoy access to the technological advances of the 3rd wave (e.g. internet access) (Schwab, 2016; Cilliers, 2018).

This is possible due to the 4th wave's characterization of much more sophisticated mechanization driven by, amongst other factors: mobile internet; smaller, cheaper and more efficient sensors; highly sophisticated hardware, software and networks; advances in artificial intelligence (AI) and machine learning; advances in genes as well as renewable energy solutions. Most importantly however, the 4th IR is characterized by the fusion and interaction of technology across physical, digital and biological domains (Schwab, 2016). Although Schwab sees positive outlooks such as a positive transformative impact across all industries; a

revolutionizing change of global value chains, enabling smart factories and increased cooperation of virtual and physical systems of manufacturing as well as rising productivity in all spheres, he mentions some emerging challenges. These refer predominantly to the supply side and possibly increasing inequalities between capital holders and labour suppliers, and short-run insecurities about substitution-effects in the labour market and in skill demands, in both developed and developing countries.

A possible outcome mentioned by Cilliers (2018) is that international trade might be rendered less important and suitable in comparison to regional trade integration. This change might be induced by changes in the set-up of supply chains and modes of production. Thus, especially in relation to the development of emerging economies such as in SSA, strong promotion of regional integration becomes necessary to promote and stimulate the potential of economic growth in the region (Tinta et al., 2018). This is in line with Baldwin (2008, 2011) arguing for increased importance of regional integration today, and showing that entering existing supply chains was of huge importance for second tier and latecomer industrializing countries during the EAM, as e.g. Indonesia, Malaysia or China. These countries greatly benefitted from joining the existing international and regional supply chains built by their forerunners. Therefore, while it took the first tier countries such as South Korea and Taiwan decades to industrialize, China was able to industrialize quicker, as there was no need to build a supply chain from scratch domestically.

The East Asian Growth Miracle

Generally the EAM is defined in terms of two tiers of countries, which followed Japan in rapid economic growth and development. The first tier refers to South Korea, Taiwan, Singapore and Hong Kong, starting their rapid and equitable growth trajectory in the 1950s and 1960s. The second tier is composed of Malaysia, Indonesia, Thailand and the Philippines and started the development journey from the 1970s onwards. In recent years, China and to a lesser extent Vietnam are added as 'latecomers', industrialising since the 1990s on an even quicker rate than the first two tiers of the EAM (World Bank, 1993).

Although the success of rapid growth is acknowledged and evidently proven, academic literature is ambiguous about the main features and key factors behind the process and two main opinions characterize debates on the topic: a market-driven view (Lin, 2011; Weiss,

2005; Gunnarsson, 2016; Lo, 2003) versus those emphasizing state-led actions (Wade, 2003; Rodrik, 1994, 2006; Wang et al. 2010).

Both strands coincide in emphasising the importance of beneficial initial conditions such as low inequality, high education of the workforce as well as good institutions and government, but differ in their view regarding government intervention. While the market-driven approach sees governments only in a supporting role by ensuring the functioning of the market and stabilizing macro-economic circumstances to facilitate development along the natural comparative advantage (Lin, 2001; Weiss, 2005), the state-led opinion centres around governmental interventions, which create a comparative advantage ahead of the economy's development stage. This refers to the concept of leapfrogging and means that industrial upgrading is speeded-up as compared to the 'natural path' of structural transformation and developing along the natural comparative advantage, led by market-forces only.

Outward orientation and participation in international trade and global value chain production leads to further accumulation of both human and physical capital as international competition is increased and the adaption of international technological advances possible (Weiss, 2005; Lin, 2011; Lo, 2003; Gunnarsson, 2016). Additionally, in opinion of the state-driven view three kinds of industrial policies were mainly applied during the EAM to enhance direct industrialization and development: Functional industrial policies, which stabilized macroeconomic circumstances (e.g. exchange rate policies); horizontal industrial policies improving various sectors and industries at the same time through investments in infrastructure, Research & Development (R&D) and small- and medium sized enterprises (SMEs); and sectorial industrial policies. These targeted specific subsectors and firms in order to promote the most efficient sub-industries and to target technological upgrading by lifting the economy artificially into higher value chain production.

While the extent of importance of the factors between and within the generations of East Asian growth and between the strands of literature differ, several key factors seem to be prevalent: macroeconomic stability, outward orientation towards international trade as well as towards foreign technology, labour market flexibility as well as good governance and a profound institutional framework (Quibria, 2002). Although global competitiveness of the economies mattered for all countries, outward orientation in terms of export and attracting FDIs differed immensely between especially South Korea and Taiwan of the first generation and all countries of the EAM. While the former focussed on investments in their domestic

market, the latter (and especially the 2nd tier countries) focussed on outward orientation to increase exports and FDIs (Page, 1994; Haraguchi & Rezonja, 2009; World Bank, 1993).

Most participants of the East Asian growth trajectories show a clear structural transformation starting from the agricultural sector, following the general structural transformation model, by increasing agricultural productivity, while shifting from employment in agriculture to employment in manufacturing and shifting from labour-intensive to more capital-intensive production. Additionally, EAME show relatively equal income and land distributions before growth took off (Wad, 2009; Kim, 1997; Rasiah, 1999) as well as a highly educated workforce and comparatively high education in relation to income levels (Rodrik, 1994; Wade, 2003). However, these initial conditions are argued to not have been prevalent in all miracle economies (Quibria, 2002). Another important factor in the EAM refers to external conditions such as low regulation governing international trade and relatively high possibilities for import substitutions to secure infant economies in the beginning (World Bank, 2012) as well as rising globalization and the emergence of global value chains (Baldwin, 2008, 2011).

Academics focussing on possible lessons drawn from the EAM focus, in line with the above, on investments into core strengths, ideas and the commercialisation of ideas by suggesting investments in human capital accumulation through improving quality and quantity of universities and education, enhancing local and regional competitiveness of the economies through cooperation and investments into infrastructure, governments and business environments (Porter, 1996; Lardy, 2012; Chang, 2006; Yusuf, et al., 2004). Thereby, social capabilities and initial conditions are improved as well, which are highly important for sustained economic growth (Rodrik, 2006).

Development and Economic Growth in Sub-Saharan Africa

Compared to the literature on growth and development in East Asia, literature on economic growth and development in SSA is less positive about the past, and more ambiguous, inconclusive and highly debating about present and future growth. Some argue that recent developments regarding productivity growth and poverty reduction give cause for optimism for future growth in the region (Diao et al., 2018; Fosu, 2018). While others emphasize that recent growth in Africa is overestimated, triggered by commodity exports, resource

abundance and benefits from high commodity prices and hence growth is not sustainable (Jerven, 2014; Rodrik, 2018; Ghani & O'Connell, 2014).

Young (2012) among others saw an African growth miracle happening, when during the early 2000s SSA's growth rates of per capita income, total factor productivity and consumption finally grew and turned positive; however, recent literature casts doubt about the sustainability of African growth and the World Bank suggests that some countries are today poorer than in 1960s (Rodrik, 2016). Some structural change shifting employment away from the least productive sector of agriculture seems to happen (McMillan & Rodrik, 2011; Gollin et al., 2014). Nevertheless, productivity is not substantially increasing, as people do not move into highly productive sectors such as manufacturing, but into low productive service sectors and informal activities (Harttgen & McMillan 2014; Rodrik, 2018; Rodrik, 2014; Iimi, 2006). Therefore, industrialisation lost ground in SSA since the mid-1970s (Rodrik, 2014), which can be seen in the fact that especially the 2nd and 3rd IR did not spread to the whole region and many people in SSA are still without access to electricity and the internet (Schwab, 2016).

Similarly, Cilliers (2018) mentions that although the situation in SSA seemed to improve since 1995, SSA is still diverging from the rest of the world in terms of incomes, as income levels in SSA rise slower than elsewhere. Additionally, extreme poverty is pervasive and tenacious. Additionally problematic is the SSA experience of moving from agriculture into other low productivity services and the informal sector, as this is growth reducing as the share of workers in high-productive manufacturing sectors decline simultaneously. This implies that aggregate growth of output per worker is declining.

Many emphasize the problem of the resource curse and declining commodity prices as explanations for the recently experienced de-growth in Africa. Rodrik (2018) mentions that both, moving into the services or the resource sectors, prevent the economies from diversifying. Less spill-over effects and inter-sectorial linkages can emerge from growth led by the resource-sector, as it is less integrated into the economy. Moreover, this sector is capital-intensive and hence does not employ many people (Guilló & Perez-Sebastian, 2015). Iimi (2006) explains that currency appreciation due to increased resource-led exports decreases the competitiveness preventing the economy from further diversification. In relation to commodity prices Collier (2007) raises the problem of their high volatility posing a greater risk for instable macroeconomic circumstances.

Cilliers (2018) adds that not only internal factors were determining SSA development and growth processes, but that conditional support from international financial institutions played an important role as well. Introduced in the mid-1980s to offer budget and balance of payments support, oversight and the implementation role of the states were substantially reduced (Page, 2017). Trade liberalization, deregulation and focus on the free market were emphasized by international organizations at the expense of having industrialisation as an option for development in SSA (Cilliers, 2018). Between 1990 and 2015 the value added of manufacturing to GDP in lower-middle and upper-middle income countries in SSA were 6-7 percentage points lower than the global average of the respective groups. This shows that SSA as a region is considerably under-industrialized and is in line with the idea that African countries might grow rapidly but transform slowly and seem to deindustrialize already as seen by the declining share of manufacturing to GDP (Stiglitz, 2013; Rodrik, 2018; Ghani & O'Connell, 2014).

Regarding future economic growth, several authors mention the importance of regional integration. The positive relationship between development, economic growth and regional integration through static and dynamic effects as well as its increasing effects on global and regional well-being is established and agreed upon in literature (Baldwin, 2003; Viner, 1950). However, regional trade agreements (RTAs) seem to have been weak and not tapping its potential in SSA. This happened through various possible reasons such as a lack of complementarity between goods (Chauvin & Gaulier, 2002), non-compliance between the member-states (Gunning, 2001), relative high trade restrictions within regional organizations, hampering growth performances (Baldwin, 2003), generally high protectionist attitudes of African regime, rendering trade liberalization meaningless (Jebuni, 1997) or generally low efficiency of African RTAs (Yang & Gupta, 2005). Nevertheless, recently the essence of regional trade and integration in the region seems to be more recognized as seen by for instance the aim to build the African Continental Free Trade Area (Ighobor, 2018). In the light of the changing global economy, changing international trade regulations as imposed by the WTO and the emerging 4th IR, regional integration especially in SSA is argued to be an important factor for successful economic growth in the future (Cilliers, 2018). And regional trade integration as well as South-South RTAs seems the better alternative for SSA than international trade integration and competition with well-developed economies in Asia, Europe and Northern America (Tinta et al., 2018).

Other alternatives for increasing economic growth and development in Africa refer to the possibility of focussing on other sectors than manufacturing, as e.g. faster convergence rates within services sector seem to yield higher possibilities for catching-up (Ghani & O'Connell, 2014). In line with this Rodrik (2018) lays down that with sufficient social capabilities alternative routes of structural transformation and leapfrogging could yield possible paths for economic growth, not based on manufacturing.

This study is placed at the intersection of the above-mentioned literatures and combines several of the aforementioned views. While it sees clear opportunities for the 4th IR for SSA it acknowledges the possible challenges and risks of missing out on the 4th IR. Further, it sees leapfrogging and therefore the conditions enabling leapfrogging in the miracle economies of East Asia as key factors of the process. Thus, this study can be placed more within the state-led approach. The concepts of leapfrogging and social capabilities as alternatives to traditional structural transformation are explored in more detail during the course of this research. The next section will introduce the theoretical framework of this study, based on structural transformation in general and the alternative possibility of leapfrogging in particular. The remainder of this investigation then assesses the possibility and feasibility for SSA to use technological advances of the 4th IR by using the strategy of leapfrogging. This is done by taking the EAM as point of reference.

2.2 Theoretical Framework

Following a Gerschenkronian approach, Abramovitz (1986) states that an advantage of backwardness exists for developing countries in the convergence with the developed world by adopting new and foreign technology. Returns to investment should be more easily raised in those economies due to their lower capital-labour ratios. Leapfrogging describes a possibility for latecomer countries to catch-up with industrialized countries. The key to this is the adoption of "more if not most, sophisticated technologies that will neither displace the capital invested nor the skilled labor of the previous technological paradigm" and sophisticated technology, relative to an economy's level of development (Soete, 1985: 416).

Additionally, the concept of leapfrogging focuses on the overall development pathway for developing countries and the possibility and extent to skip particular steps and stages, which

have not proven to be growth enhancing in earlier development journeys. Provided through the "international diffusion of technology" developing countries are enabled to "jump particular technological paradigms" (Soete, 1985: 416). Latecomer countries have two main advantages: 1) avoiding incomplete technologies at early stages of development, which are related to high costs due necessary investments in R&D, and, 2) having access to cheaper, further developed technologies. These advantages can be seen for example during the EAM, where less developed economies such as Malaysia, Indonesia, Thailand and the Philippines took over technology and production processes of the further developed economies of South Korea, Taiwan, Singapore and Hong Kong, and joined the value chains of these economies.

Additionally latecomer countries can avoid 'misplaced' investments in older and superseded technologies and can hence catch-up through differently allocated innovation (Perez & Soete, 1988). Furthermore, latecomer countries are not centred on prevalent technologies and therefore it might be easier to use the window of opportunity open by newly developing technologies as they are not locked into current technological processes and systems such as more advanced economies. Perez and Soete (1988) add that leapfrogging into newly developing industries and technologies provides the advantage of growing with the technology. Early-entry into an industry requires knowledge residing in the public domain rather than more sophisticated, developed technologies asking for more advanced knowledge, which might be less available in latecomer countries.

Lee and Lim (2001) developed two paths of leapfrogging within the catching-up process: 1) path-creating catch-up and 2) path-skipping catch-up. The former implies that the latecomer catches-up with more advanced economies, but does so through adoption of more sophisticated technology. Using the window of opportunity to enter newly emerging technologies, these countries embark on a new development path and enjoy the possibility to take-over technological leadership in newly emerging industries. An example of path-creating leapfrogging was seen during the Korean growth trajectory in the development of digital TVs by Korean firms. Closely watching technological trends in the forerunner Japan, Korean firms embarked a path-creating leapfrogging process by extending their experience of building analogue TVs, using foreign knowledge, and developed the first digital TV (Lee, Lim & Song, 2005).

The latter, path-skipping catch-up refers to the pure adoption of more sophisticated technologies, provided through international diffusion. Latecomer countries on this path

catch-up with more advanced economies by skipping stages of their development trajectory. However, overall they follow the same path (Brezis, Krugman et al., 1993; Chen, 1999; Amitic, 2001). This can be widely seen in SSA and the use of mobile phone technology. While mobile phones are today widely spread over the region, only few households ever used landline technology. This shows that the region skipped the less effective, sophisticated and less useful technology of landline phones by directly jumping into using mobile phones.

Linked to this, Rodrik (2014) explains the possibility to 'leapfrog' the manufacturing sector and instead directly emphasize the services sector. By this Rodrik proposes an alternative path to the 'traditional' structural transformation process, influenced through leapfrogging. Structural transformation is referred to as the 'natural development path' and consists of the long-term changes in an economy concerning the composition of employment and output of the three sectors of an economy (agriculture, industry (& manufacturing), services). It is characterized by the shift of shares of employment and GDP value added from the agricultural to the industrial and manufacturing sector and accompanied by rising urbanization, demographic changes such as lower mortality and fertility rates as well as consequences for economy and society in terms of production, income, and inequality among others (Kuznets & Murphy, 1966; Timmer, 1988; 2007; Timmer et al, 2009; de Vries et al. 2015).

Rodrik (2014) shows that due to the changed external circumstances of increased globalization, and China remaining highly prevalent and competitive in manufacturing due to its high supply of cheap labour, latecomer countries have to find other paths. Ghani and O'Connell (2014) add that growth for developing countries does not necessarily have to be rooted in the manufacturing sector. Data suggest that convergence within the services sector is higher and faster than within manufacturing at the moment. Hence, leapfrogging cannot only provide the possibility of speeding up the structural transformation process through more sophisticated technology and skipping or creating new paths but it even provides for an alternative way of economic development, by leapfrogging economies into the services sector instead of the manufacturing sector.

Nevertheless, Ghani and O'Connell (2014) as well as Rodrik (2014) emphasize the importance of social capabilities and initial conditions in the relation to technological leapfrogging in general and in particular in the context of embarking a development process different from the traditional structural transformation. While not the sector itself is determining for successful growth and catching up, successful and sustainable adoption of

technology and hence economic growth depends on the availability of social capabilities to absorb and integrate new technology and to translate it into economic growth.

Considering this, the concept of leapfrogging relates to models of economic growth by re-emphasising the role of technology within the growth process (Solow, 1956). As technology can be imported from exogenous sources as well as developed from within a country, leapfrogging can be placed within both the Solow-related as well as endogenous growth models.

Additionally, initial conditions need to be in place to apply the strategy of leapfrogging and to absorb and efficiently use technology by leapfrogging. Thus, the concept links to the more recently emerged emphasis on social capabilities in the context of economic growth centring around two main elements: 1) the socio-political structure and 2) technological capabilities (Ohkawa & Rosovsky; 1973, Abramovitz, 1995). Among other social capabilities refer to institutional quality, capacity of states, education and social inequality (Gunnarsson, 2016). Andersson and Palacio (2017) define the concept of social capabilities more specifically and introduce four dimensions: accountability, autonomy, inclusion and transformation.

Placed in the general theoretical field of economic growth and structural transformation, and embedded in the more specific theoretical framework of leapfrogging and social capabilities, this research focuses on the possibilities to apply leapfrogging in the context of SSA and the 4th IR. It suggests that the window of opportunity due to the 4th IR opens the possibility of a path-creating catch-up, if the right social capabilities are in place and a basis for successful leapfrogging in SSA is available. This research's analysis sheds light on the question whether this is the case by assessing the presence of the factors, which enabled the EAME to leapfrog their development paths, in SSA.

2.3 Analytical framework

This section sets out to firstly, introduce the method used to analyse the overall question of this study of whether SSA could use the strategy of leapfrogging to use the 4th IR to enhance economic growth of the region. Secondly, the operationalization of the method in the context of SSA and the 4th IR is explained as well as the data collection and source selection.

2.3.1 Analysing Methods

This research's analysis is based on the approach of a 'Qualitative Comparative Analysis' (QCA) as developed by Ragin (1987). A QCA approach facilitates a "holistic comparative analysis of cases, treating each case as a combination of or configuration of conditions, and cases are compared as configurations" (Ragin, 1991: 5). A QCA aims at specifying and analysing a combination of events and factors, which explain "presence or absence of a particular outcome" (Bradshaw et al., 1995: 47). The first step of a QCA approach is to find possible causal conditions for a specific outcome. Once possible conditions for an outcome are identified the researcher determines how the conditions match-up within different cases, countries or situations. The cases are compared by constructing truth tables and allocating a "1" whenever a condition or factor is observable, while a "0" indicates absence of the factor. By applying a truth table to compare the significance of the conditions between the different cases, the significance of the condition for the outcome is analysed. Table 1 provides an example of a truth table in relation to a QCA approach. The example in Table 1 shows that conditions 1 and 2 lead to the appearance of the specific outcome while condition 3 seems to have an insignificant effect (Bradshaw et al., 1995).

Table 1 - QCA truth table example

Case	**Possible conditions**			**Outcome**
	Condition 1	Condition 2	Condition 3	
Case 1	0	0	0	0
Case 2	1	1	0	1
Case 3	1	0	0	1
Case 4	1	1	1	1
Case 5	0	1	0	0

Construction by author, following Ragin (1987) & Bradshaw et al. (1995).

Generally, QCA combines the strengths of qualitative and quantitative methodologies and thereby addresses critiques on both. While quantitative research is criticized for being too simplistic and too dependent on variables, qualitative methods are castigated for being too subjective and imprecise. QCA addresses these critiques by being qualitative in nature

however additionally it identifies precise combinations of factors and conditions leading to a specific outcome. Therefore, QCA incorporates and combines the precise measures of quantitative analyses as well as the holistic and detailed argumentation of qualitative studies (Griffin, Botsko, Wahl, Issac 1991; Bradshaw et al., 1995).

Although QCA inherits many advantages and facilitates theory building as it pinpoints to specific factors and conditions, which explain certain events and outcomes, some problems occur. Firstly, while the researcher is highly flexible in choosing the variables, substantive knowledge of the topic is necessary to choose relevant variables. Secondly, as the final truth table is based on categorical data, precision is highly important in how to measure the categories. Further, using categorical data makes it difficult to use measures based on number ranges and translation into nominal scale measures might be necessary. Nevertheless, Ragin (1987: 86) points out that this is unproblematic as conditions and outcomes and their presence or absence are qualitative phenomena and hence "already nominal scale measures". Thirdly, QCA's have the risk of becoming very complex, as the amount of causal variables is not limited, making possible combinations in the truth table possible. Therefore, the researcher has a main task in logically minimizing the data reported (Bradshaw et al., 1995). Fourthly, subjectivity of variables is raised as a general concern of empiric studies. Bradshaw et al (1995) argue however that QCAs are not more subjective than more traditional methods of analysing specific cases. Lastly, comparability is highly important in the context of QCAs. However, as long as reasonable categories, conditions and factors are defined for the outcome on question, comparability is not problematic. Further coding the categories (conditions) clearly as absent ("0") or present ("1") is necessary as well as the use of constant and related assessments of the categories (conditions) in all cases (Bradshaw et al., 1995).

QCA has been applied in different contexts such as unionization in developed countries (Griffin et. Al, 1991), employment discrimination (Ragin & Bradshaw, 1991) or the appearance of revolutions in Latin America (Wickham-Crowley, 1991). Bradshaw et al. (1995) suggest that, due to its multi-factor and multi-level analysis, QCA is perfectly suited for analyses of growth in the African context. Additionally, as mentioned by Schwab (2016) the 4th IR will influence various dimensions, factors and levels. Therefore, QCA is adopted in this setting to fit the specific circumstances of assessing the presence of the factors permitting the EAME to use technological leapfrogging for economic growth in SSA. The specifics of the QCA of combining qualitative and quantitative data makes this approach in particular

applicable to this research's main question and its context. By complementing quantitative data with qualitative data, missing as well as inconclusive quantitative data can be complemented and substituted by qualitative data. This is of special importance in the given case, as historical quantitative data for the EAME might not always match recent data for SSA and hence demands qualitative explanation, interpretation and discussion.

2.3.2 Operationalization

This research is based on the basic idea of the QCA approach, however the method is adapted to serve this study's purpose. The set-up of the QCA is slightly changed, as this research does not focus on analysing possible conditions and their presence in different cases of a specific outcome. Rather, the absence and presence of given conditions is assessed in order to evaluate the chance of a specific outcome in an additional case. The outcome in this study refers to the successful adoption of the technological leapfrogging strategy to enhance economic growth. Technological leapfrogging has been successfully adopted in the EAM and thoroughly studied, as explained above. Therefore, the QCA approach is linked to the factors and conditions, which are identified as crucial in the process and made it possible for the EAME to adopt technological leapfrogging and translate it into economic growth. These conditions' absence and presence will be assessed for the case of SSA and the 4th IR in order to analyse the possibility of adopting technological leapfrogging in this context.

The factors and conditions identified as relevant are based on the primary factors developed and examined by Quibria (2002). He defines the primary factors as apparent in all EAME. Additionally, the analysis includes several secondary factors, which have not been present in all EAME to the same significant extent, but have been very important and supported growth of the economy and development substantially in some of the economies (Quibria, 2002). Table 2 indicates the factors and conditions inherent to the EAM. Furthermore, the table summarizes how the factors and conditions are measured in the African case.

Table 2 - Operationalization of QCA

Factor/Condition from Asian miracle	Measurement Indicator	To measure what? (Significance of factor/ condition for success)
Primary Factors		
Macroeconomic stability	• Inflation rate developments • Budget deficit	Maintenance of stable economic environment • To maintain export competitiveness • To enhance investments in economy & businesses • To sustain growth
Openness to trade	• Export & Imports to GDP • Current account balance • Tariffs, duties & customs burdens • Competitiveness (market sizes…)	• Participation in international trade • Facilitates exchange of products, knowledge and technology • Establishing global linkages
Openness to innovation & technology	• Investment rates • Research & Training • Technology & Innovation • R&D expenditure	• Possible support of inclusion of new technologies into production • Ability to adapt and use new (foreign) technology • Environment to build up on technological advance → endogenise foreign technology, extend it, provide access for whole population
Labour market flexibility	• Qualitative assessment • Labour market efficiency • Labour market flexibility index	• Adaptability of labourforce and labour-market to changing employment structures, increasing technology, real wage developments
State capacity (Institutional Framework)	• Corruption • Property rights • Institutions • Accountability	• Effectiveness of government institutions, rules & regulations • Stable governance, political, institutional environment • Business friendly environment • Shared growth
Secondary Factors		
Agricultural/ Structural transformation	• Sectoral shares of value added to GDP • Sectoral employment developments	• Extent of industrialisation (significance of manufacturing, total volume of manufacturing) • Mix of production • Raising productivity • Increasing technology • Linked to improving infrastructure & accompanying investments to use technological advance and embed new technology into industry & society • Link to broad based economic growth & equality of opportunity to reach and participate
Income inequality	• GINI • CPIA social inclusion index	• Possibility for whole population to benefit & participate in process • Possibility of '*broad based economic growth*'
Human Capital	• Literacy • Schooling & Enrollment • Life expectancy • HDI	• Country's ability to respond to shifts in labour market • Labourforce capabilities • Participation of whole population • Adoption & absorption of technology

Construction by author. Specific outcome: Economic Growth through leapfrogging; Set of factors/conditions: Primary & Secondary factors for East Asian Miracle, following Quibria (2002).

The analysis of absence and presence of the factors and conditions providing for successful leapfrogging in the EAM takes into account the changed circumstances and differences in the setting, by thoroughly discussing the analytical results in the context of the current context and developments. These differences are namely 1) different timing: 2020 versus 1960s/1970s, 2) different setting: SSA versus South-East Asia, 3.) different kinds of

technology and a different wave of industrial revolution: 4th IR and more sophisticated, smaller apparatus and not necessarily tangible things versus mechanization, mass production and starting computerization of the 2nd and 3rd IR.

The development process in SSA is about to start, while in Asia the development trajectories started around 50 years ago. During this time the international setting, international trade as well as the process of development changed. Additionally, the compared regions differentiate in dimensions such as culture, politics and economies. Lastly, the technological advances providing ground for leapfrogging refer to a different kind of technological change. While some factors, such as macroeconomic stability, labour market flexibility, governmental and institutional quality as well as human capital are less effected by these changes, openness to international trade and the extent of traditional structural transformation seem to be less significant today than earlier. These differences in the importance of factors are approached in the discussion of the analytical results. Not accounting for these differences in the set-up could lead to deficiencies and limitations of the study, as e.g. restricting internal and external validity of the results. Taking into account these differences is hence important and gives ground for using a QCA approach. Further, the QCA approach provides the opportunity to use qualitative as well as quantitative data to assess the conditions in SSA to follow the East Asian example to use technological leapfrogging to enhance economic growth.

In order to account for the heterogeneity of the countries of SSA, the region's countries are divided into three groups (summarized in Appendix A): Group 1, composed of Botswana, Kenya, Mauritius, Namibia, Rwanda and South Africa, represents the group of the most competitive and advanced countries according to the Global Competitiveness Index (GCI) from the Global Competitiveness Report (GCR) (WEF, 2018a). These countries score at least 4 out of 7 in the overall index and hence score in the world's middle to upper-midfield, being comparably competitive to some EU economies and more advanced than most Latin American, South Asian or other African economies. The second group comprises Benin, Cameroon, Cape Verde, Ethiopia, Gabon, Gambia, Ghana, Guinea, Senegal, Seychelles, Tanzania, Uganda and Zambia, these countries score lower than the first group countries but still above the median of 3.5. They are less competitive than most other economies in the world and only a few Latin American as well as SSA economies score below them. The last group comprises the least competitive and advanced countries of the region, Angola, Burkina

Faso, Burundi, Chad, Democratic Republic of Congo, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Nigeria, Sierra Leone, Swaziland and Zimbabwe.

Due to data availability a few countries are left out from the GCR and these are consequently not included in this analysis either. The countries are aggregated into groups due to data availability and the scope of this paper as well as to facilitate comparison. As competitiveness is highly important in relation to attracting FDIs and foreign technology as well as to take part in technological advances of the 4th IR, grouping along the lines of the GCI is most relevant for this research. Alternatively, the region's countries could be grouped along lines of income, as provided for by e.g. the World Bank. However, this is difficult in particular in the case of SSA, as the rankings could be biased by oil exporting or resource rich countries.

Finally, after analysing and assessing the extent to which the factors and conditions are fulfilled in the case of SSA at the edge the starting 4th IR, a truth table is designed. Table 3 shows the truth table, which is completed at the end of the analysis and provides the basis to answer the question on whether SSA has the necessary conditions to adopt technological leapfrogging as a strategy to use the 4th IR to enhance economic growth and development.

Table 3 - Proposal of Final Truth Table

Factor/Condition	**Appearance in group 1 ("1" if observable; "0" if not observable)**	**Appearance in group 2 ("1" if observable; "0" if not observable)**	**Appearance in group 3 ("1" if observable; "0" if not observable)**
Macroeconomic stability			
Openness to trade			
…			

The possible challenges of a QCA approach are addressed as follows. The research's setup - assessing the presence of a given and proven set of conditions and factors in a different case - solves the challenge of possible complexity of the truth table and the analysis. Additionally, precision and relevance are guaranteed as well as subjectivity avoided by using qualitative academic evidence on the set of conditions and factors assessed for the outcome. Focussing on one author, however taking into account various other authors on the same topic ensures objectivity and coherence in the selection of factors determining the applicability of

leapfrogging. Following the categories and measurements described in column 3 of Table 2 ensures comparability. This settles possible differences in measurement due to data availability of the cases.

2.3.3 Data collection, source selection & case selection

This research uses quantitative as well as qualitative data. While a focus is put on using quantitative data to measure and compare the extent of presence of the factors and conditions in SSA, data availability restricts this and when necessary qualitative data is used to support, complement or substitute for quantitative data. This is in particular the case for data on the development process of the EAME as historic data on the different factors and measures from those economies is more scarce, as for example employment measures, which are available from 1991 onwards only (World Bank), or as seen by the example of Taiwan, for which due to various reasons, data is rarely available from the big databases such as the World Bank.

Quantitative data is retrieved from various well-known sources such as the World Bank Development Indicators, the IMF database, UNDP data and in particular from the World Economic Forum's GCR. It provides a multi-layered assessment of countries' and their economies' competitiveness along 12 pillars. These involve institutions, infrastructure, economic indicators, indicators for education as well as the efficiency of labour, goods and financial markets, their production processes, responses technology as well as the countries' domestic and international market size. This multi-factor index hence provides a profound assessment of the world's countries, and although some countries are left out, it includes information on 110 variables in 137 countries (2018 version). Most indicators employed in this research reach from 1 (worst) to 7 (best) if not indicated otherwise. While historical data on the EAME is more difficult to retrieve, data and indices measuring the extent of the abovementioned factors in SSA is widely available. The data is analysed by simple numerical comparisons and set into context by the use of supportive, qualitative data.

Although, widely acknowledged databases are used, data reliability is always an issue if dealing in particular with developing countries. Reliability issues may arise from the setup and implementation of surveys in the countries, inconsistent as well as incomplete data collection (Jerven, 2014). Dealing with historical data of EAME as well as with data for SSA countries, this research takes into account possible data reliability issues as limitation of its

results. Additionally, by adopting a QCA approach this study benefits from complementing quantitative data with qualitative data, which reduces dependency on quantitative data and hence reduces the impact of possible data reliability issues on the results.

Another issue in the relation of the quantitative data used in this research and its results derives from the heterogeneity of the SSA countries. Although this research accounts widely for the countries' heterogeneity in the different factors, grouping always implies averaging and hence the risk of missing out on outliers. Missing out on outlier observations restricts legitimation and possibly external validity of the results. However, as the group averages are constructed out of per country observations by the author, positive as well as negative outliers are observed and indicated throughout the analysis.

Qualitative data from different kinds of sources is used in order to incorporate different points of view and thereby minimizing bias of author's or source subjectivity. The basis of this research's analysis is built on factors and evidence on the EAM, provided by Quibria (2002). Quibria (2002) refers to data from highly renowned data sources, which increases data reliability. While his work is widely accepted, this research complements it with evidence from other academics in the field, such as Page (1994). In particular secondary sources such as academic articles and journals are used. Furthermore, reports of private sector investors and international organisations are employed. Qualitative data provides important information to form the basis of the analysis and to set the quantitative comparison into context. Data is analysed by using the widely used scientific approach of a content analysis, which allows for replicable interferences between data and its context. Thereby, new aspects are provided and the data is framed from the beginning in a coherent way (Elo & Kyngäs, 2008).

In the case of SSA the most recent year available is used for quantitative data (2016 to 2018), in order to assess the potential of using technological leapfrogging to enhance economic growth via the 4th IR, which is currently emerging. In the case of the EAME a distinction is made between 1st and 2nd tier countries. In order to increase the validity of the QCA, the years of the start of each tier's development trajectory is used, 1960/1965 for 1st tier and 1970/1975 for 2nd tier countries. To enhance clarity of the comparison and due to data availability, not all EAME are taken as reference points for all factors assessed. Korea provides the best point of reference of the 1st tier countries. Due to the special setting of Hong Kong and Singapore being city-states, their comparability with SSA countries seems less valid and data availability and the political situation with China decreases Taiwan's suitability. In order to increase

internal validity, Malaysia is taken as point of comparison for second tier countries as Malaysia's development process is most similar to the Korean example.

The case of SSA in relation to the 4th IR is selected as focus of this research as it provides a highly interesting and scarcely covered case. While media shows recently growing interest in the topic, academic research is still very scarce. The region as well as the context of the 4th IR is highly relevant and an up-to-date topic. EAME are chosen as point of comparison as they pose the most significant and successful example of a whole region experiencing rapid and sustained economic growth, using the strategy of technological leapfrogging. Further, although differences between the regions and the technologies adopted are apparent, the strategy of technological leapfrogging as such remains the same in the SSA context. In this relation it is important to re-state that this study is not aiming to analyse whether SSA can replicate the EAM and its development path. It rather sets out to assess whether the region SSA is equipped to use the same strategy, adapted to today's context of the 4th IR and changed external circumstances, to enhance economic development.

3 Empirical Analysis

3.1 Results

This section analyses whether the factors, which enabled the EAME to follow a strategy of technological leapfrogging to enhance sustained economic growth, are now fulfilled in SSA and could lead to economic growth through technological leapfrogging into the 4th IR. The factors of the EAM are assessed one after another, explaining its significance during the EAM and comparing data from EAME and SSA countries. This is done following the definition of primary and secondary factors by Quibria (2002). If quantitative data is not available for EAME, arguments build on qualitative empirical evidence from the vast literature on the EAM. In order to account for the heterogeneity of countries in SSA, the region is subdivided into three groups, as outlined in Section 2.3.2 and summarized in Annex A, following their performance in the GCR. Group 1 refers to the most competitive and advanced countries in SSA, according to the GCR, scoring at least 4 out of 7. Group 2 refers to countries scoring between the median score 3.5 and 4. The last group is composed of countries scoring below 3.5, being least competitive and advanced not only within SSA, but also globally.

3.1.1 Primary Factors

This subsection sets out to analyse whether SSA provides a sound basis to adapt the strategy of technological leapfrogging in the context of the 4th IR, based on several factors, which proved significant during the EAM. Therefore firstly, in line with Quibria (2002) and Page (1994) the presence of the following primary factors during the EAM, 1) macroeconomic stability, 2) openness to trade, 3) openness to technology & innovation, 4) labour market flexibility and 5) institutional framework and governance quality are assessed, before the presence of secondary factors of agricultural transformation, human capital and inequality are examined.

a) Macroeconomic stability

Macroeconomic stability was of great importance to the success of the EAM in reaching sustained economic growth. Building and maintaining a stable macroeconomic environment was crucial to enhance and attract foreign and domestic investments into the economy and businesses as well as building a framework for investments into education, integrating the banking system and enable productivity improvements (Heliso, 1994). Additionally, stable macroeconomic factors secure export competitiveness of the economies. The EAME reached and retained macroeconomic stability by avoiding volatility of the real interest rates, ensuring largely positive rates and price stability. Inflation was not low in all countries, however, all economies maintained either a budget surplus or kept the budget deficit small, financing it in a prudent manner, and limited internal and external debts. This enabled the EAME to follow realistic exchange rate policies avoiding overvaluation and retaining export competitiveness (Quibria, 2002). Table 4 shows time period averages of the inflation rate and the overall budget deficit for the respective economies.

Table 4 - Macroeconomic indicators East Asian Miracle Economies and SSA compared

	Inflation rate (annual, %)			**Overall budget deficit (% of GDP)**			
East Asian Miracle	***1961-1970***		***1971-1980***	***1961-1970***		***1971-1980***	
Hong Kong	2.41		9.21	n.a.		0.70	
Korea	12.51		16.48	-0.76		-1.71	
Singapore	1.11		6.72	1.55		1.07	
Taiwan	2.80		11.11	n.a		1.40	
Indonesia	210.57		17.48	n.a		-2.61	
Malaysia	0.93		5.98	n.a		-6.32	
Thailand	2.32		9.98	n.a		-3.10	
SSA	***2006-2009***	***2010-2013***	***2014-2017***	***2004 – 2008***	***2009 - 2012***	***2013-2015***	***2016 - 2019***
Group 1	9.15	5.68	5.44	-1.82	-5.38	-5.16	-5.21
Group 2	11.84	8.56	4.26	-3.27	-4.78	-5.12	-4.75
Group 3	9.27	8.69	5.99	-4.55	-6.1	-6.83	-7.36

Sources: Quibria (2002), World Bank Development Indicators (2019), IMF database (2019); Composition by author.

Recent investigations suggest that macroeconomic stability has been delayed in SSA due to policy uncertainties, terms of trade shocks and rising debt levels (IMF, 2019). Table 4 compares the three groups of SSA countries: the countries of Group 1 show the most stable inflation rate over the periods, however, the second group managed to decrease inflation since 2006 most significantly. Recent data suggest that although recently, inflation has been slightly rising, the current inflation level is relatively constant. The least competitive countries in SSA

managed to decrease inflation at a similar pace as the most competitive countries. However, recently, they are experiencing rapid increases again, from 2016 to 2017 inflation in this group rose from 5.99 to 9.5 % (World Bank, 2019). In terms of budget deficit the groups cannot be distinguished as easily. All groups experienced increasing budget deficits since 2004, while the group of medium competitive countries managed to decrease the deficit slightly most recently (World Bank, 2019).

Comparing the annual inflation rate in percentages of the recent years (2014 – 2017) in SSA countries to the inflation rate of the starting periods in the 1st and 2nd tier countries (1961-1970 and 1971-1980, respectively), SSA countries score in between the EAME. Inflation rates are higher than in Singapore or Malaysia, economies, which relied and focused on low inflation however, they are smaller than in Korea or Indonesia. In terms of budget deficit however, all three groups of SSA countries score worse than the EAME during their starting period, only Malaysia stands out with a relatively high budget deficit compared to other EAME, but very similar to SSA countries' budget deficits.

The GCR rates the macroeconomic environment of SSA as a region rather low, scoring 3.9/7, here the heterogeneity of the region becomes obvious with the better developed countries of group 1 scoring 4.54/7, medium developed scoring 4.04/7 and least developed scoring 3.47/7. Countries of group 1 score better than the average of Eurasia and the Middle East (4.4/7) (WEF, 2018b). Within the groups, outliers exist. In group 1 Kenya sticks out by only scoring 3.6 and hence lower than the overall SSA average, while Botswana provides extremely high macroeconomic stability, scoring 6.1. Similarly, Gambia and Ghana score have substantially lower macroeconomic stability than the rest of the group scoring only 2.5, whereas Ethiopia scores higher than the average of group 1. While group 3 is generally more homogenous, 2 outliers on the lower end can be observed, namely Mozambique and Malawi, scoring 1.86 and 2.18 only.

This fits the general impression that macroeconomic stability in SSA is deteriorating recently. The World Bank mentions that although a few bright spots emerged and persist, and attract global and domestic investments, SSA scores last among the emerging markets in its macroeconomic stability and growth prospects are below emerging markets' average (Campbell, 2019). Nevertheless, the heterogeneity of the region should be taken into account as seen with the differences among the three groups showing that the more developed countries have a generally more stable macroeconomic environment than the rest of the

region. Taking into account the measures above and the fact that Malaysia managed to embark its growth trajectory with a larger budget deficit as group 1 and group 2 SSA countries, the macroeconomic basis for countries of these groups seems to be present. However, this is reduced by the increasing pattern of budget deficits in the countries and is thus not ensured to last in the future. Group 3 seems to experience too heavy macroeconomic instability

b) Openness to trade

After following import substitution before growth took-off, the EAME turned into more outward oriented economies, by lowering tariff rates and export taxes, removing quantitative restrictions on trade as well as by reducing barriers to international investment flows (Quibria, 2002). Anti-export biases were avoided even in areas with higher protection and where competitive exchange rate policies were adhered. Provision of easy access to inputs at world market prices was guaranteed by duty exemptions and free access to foreign exchange. Additionally, new institutional developments such as export processing zones led to benefits from increased export without running into problems of across the board liberalization and retaining protection from import-substituting industries was possible (Quibria, 2002). Table 5 shows the already low average tariff rates in the beginning of 1970s in Korea and Malaysia, this provides empirical evidence for the openness of the economies. Further, Table 6 provides data on exports and imports as percentage of GDP, indicating relatively high numbers for Hong Kong and Singapore during the 1960s already, followed by rapidly increasing shares of imports and exports and hence participation in international trade in Korea, and Malaysia in the 1970s and 80s.

Orientation towards exports and other economies was very important as rising exports raised the capacities to import inputs as well as more sophisticated technology (Quibria, 2002). Furthermore, export orientation increased skill formation as it increased the pressure for training and learning among the population to adapt to new technologies and to meet the complex requirements of Western countries.

Table 5 - Average Tariff Rates East Asian Miracle Economies & SSA

	1970s	1990s
Korea	9%	<5%
Malaysia	9%	<5%
Indonesia	n.a.	<5%
Thailand	13%	<5%
SSA	**2018**	
Group 1	6.67%	
Group 2	10.56%	
Group 3	10.92%	

Composition by author; Data Sources: Quibria (2002); World Bank (2018); WEF (2018b).

Table 6 - Exports, Imports & Current Account balance in East Asian Miracle Economies & SSA Countries

	Exports % GDP	Imports % GDP	Current Account balance
East Asian Miracle 1st tier	**1960s**	**1960s**	n.a.
Hong Kong	79.68	81.70	n.a.
Korea	8.91	19.18	n.a.
Singapore	118.72	129.73	n.a.
Taiwan	21.58	23.64	n.a.
East Asian Miracle 2nd tier	**1970s**	**1970s**	n.a.
Indonesia	24.42	19.50	n.a.
Malaysia	45.73	41.71	n.a.
Thailand	19.91	23.68	n.a.
SSA	**2018**	**2018**	**2018**
Group 1	34.53%	44.57%	-2.90%
Group 2	30.80%	45.61%	-7.25%
Group 3	22.35%	46.54%	-7.34%

Composition by author; data sources: Quibria (2002); WEF (2018b); World Bank (2018).

Comparing the different SSA groups among each other and to the EAME, SSA countries are relatively homogenous in terms of imports, whereas they differentiate slightly in exports; more developed and more competitive SSA countries having higher exports (Table 6). Additionally, SSA countries of groups 1 and 2 clearly score higher than 1st tier countries Taiwan and South Korea in terms of exports, while they are substantially lower than in Singapore or Hong Kong in the 1960s. Similarly, Thailand had lower exports than SSA countries of groups 1 and 2, while group 3 countries have similar amounts of exports relative to GDP in their starting period during the 1970s, while Malaysia had higher exports as percentage of GDP (Table 6). Imports as percentage of GDP show a similar pattern

comparing SSA in 2018 to EAME in 1960s and 1970s respectively. Imports in the initiating growth phase in Singapore and Hong Kong, were higher than in all groups of SSA countries, while South Korea, Taiwan and Indonesia had significantly lower imports as percentage of GDP than SSA. Malaysia had about the same level: 41.7% to 45.8% in SSA.

Nevertheless, the current account balance in 2017 was negative for all SSA country groups (Table 5). In addition, the WEF (2018b) suggests that heterogeneity of the market and in terms of trade barriers is high among SSA countries. The three groups differ significantly in terms of tariffs, trade barriers as well as market size (Table 6 & Table 7). This data suggests that group 1 is relatively competitive, having relatively low tariffs and trade barriers as well as an average market size and above average competitive advantage compared to world averages. Noteworthy is that Mauritius sticks out with tariffs of only 0.75% of duty, which is significantly lower than the rest of the group. Both, group 2 and group 3 are very homogenous in terms of openness to trade. Group 2 scores slightly worse than group 1 and group 3 countries fall substantially behind. Comparing to the EAME, average tariff rates of EAME were higher compared to group 1, while they were only slightly lower than in group 2 and 3.

Table 7 - Trade openness measures SSA countries, 2018

	Market size	**Nature of competitive advantage**	**Trade barriers**
Group 1	3.33	3.79	4.44
Group 2	2.86	3.18	4.06
Group 3	2.55	2.72	3.65

Composition by author; data source: Quibria (2002); WEF (2018b)

Overall the measures suggest that the countries of group 1 have, compared to EAME, a better base, while countries of group 2 are slightly less open to trade than EAME at their growth initiating period, while group 3 countries lack behind.

c) Openness to technology & innovation

Closely related to general outward orientation and openness to trade and exports, is the search for and openness towards foreign technology via technology transfer through licenses, imports of intermediate goods and capital as well as foreign training. It was inherent to the possibility to use leapfrogging and the success to sustain economic growth during the EAM. Further, it was closely related to high saving and investment rates. Firstly, the accumulation and import of new technology and its adoption led to vast investments into human capital and

hence a domestic investment boom to retain competitiveness by adapting and moving towards more sophisticated technologies (Quibria, 2002). Additionally, investments into infrastructural advances were made, as the creation of good infrastructure is complementary to private investments and growth enhancing (Quibria, 2002). This was supported by the creation of an investment-friendly environment, so that FDIs and other means of technology inflows were further attracted and retained. Domestic investments were attracted by credit guarantees and spreading the risks from private to the public, whereas foreign investments were enhanced through tax policies, avoidance of high tariffs and low relative prices of capital goods (Quibria, 2002; Page, 1994).

While the group of second best competitive SSA countries score best (IMF, 2019), all three SSA country groups show relatively higher investments as percentage of GDP in 2018 as e.g. 1st tier industrializer South Korea, as opposed to approx. 7.5% (FRED, 2019) respectively. Groups 1 and 2 are relatively homogenous in terms of investments, group 3 faces two outliers, namely Zimbabwe and Burkina Faso, which on average had investments of approximately 5% only during the last two decades, and thus had substantially lower investments than other SSA countries as well as Korea. However, different indicators of the openness towards technology and innovation provided by the GCR show that while the least developed and least competitive countries in SSA fall clearly behind in this condition (Table 8). They score always significantly lower than world average. This suggests that advanced technology is neither sufficiently entering these countries, nor is the imported technology absorbed or successfully integrated into the economy. Furthermore, technology cannot be developed from within the countries, as the basic conditions of R&D development, scientific research and training of the workforce seem to be not really fulfilled. An exception to this poses Nigeria, generally scoring considerably higher than other countries of the group, being close or even above to the averages of group 2 countries.

Table 8 - Indicators for openness to technology & innovation SSA, 2018

	Group 1	Group 2	Group 3	Comparison	
				World average	World without SSA
Investments (%)	20.2	29.1	18.4	*n.a*	*n.a*
Technological Readiness (1-7)	3.89	3.06	2.49	3.98	4.28
Technological Adaption	4.68	4.13	3.42	4.38	4.54
Innovation capacity	4.30	4.08	3.30	4.08	4.22
Firm-level tech absorption	4.68	4.15	3.5	4.37	4.53
Availability of latest technology	4.90	4.19	3.43	4.59	4.77
Availability of research & training	4.40	4.32	3.56	4.27	4.40
R&D expenditure (% GDP)	0.5	0.39	0.2	*n.a*	*n.a*
Company spending R&D	3.57	3.13	2.78	3.38	3.35
Government procurement of advanced technology	3.79	3.57	2.94	3.33	3.41
Quality of scientific research	3.85	3.48	2.90	3.74	3.93
Attracting talents	3.99	3.37	2.98	3.29	3.43
University-industry collaboration R&D	3.66	3.36	2.83	3.45	3.60
FDI transfer	4.45	4.08	3.34	4.18	4.34
FDI (% GDP)	2.15	5.52	6.0	*n.a*	*n.a*

Composition by author; data sources: WEF (2018b); World Bank (2018), IMF database (2018).

Additionally, Table 8 shows that countries of group 1 score for 10 out of 12 indicators higher than world average without SSA, only the quality of scientific research is slightly below world average without SSA, however still above general world average. Noteworthy, South Africa and Rwanda score even higher than the group average and stick out positively in particular in attracting talents; availability, absorption and adaption of foreign technology as well as in R&D collaboration and investments. Nevertheless, group 1 countries fall substantially behind in technological readiness. Group 2 scores in 8 out of 12 indicators below global average. While it falls significantly back behind global average in technological

readiness, it scores above global average in terms of innovation capacity. This is influenced by the government's procurement of advanced technology and the countries' ability to attract talent. Group 2 seems relatively homogenous in these regards. Only the Seychelles sticks out positively scoring considerably higher in most indicators concerning technological readiness, R&D investments, FDI transfers and adaption and absorption of technology. While FDI in group 3 are highest among SSA countries, these countries fall significantly behind in all indicators concerning technological openness and the use of foreign technology. Nevertheless, here another exception needs to be stated, namely Nigeria, which scores substantially higher than the rest of group 3 in FDI transfer, technology adaption and absorption.

Group 2 as well as group 1 hence shows openness towards foreign and more sophisticated technology as well as the capacity to use and improve innovations. The data suggests that currently the environment to adjust to foreign technology improves in these countries. Comparing the percentage of GDP spent on R&D, countries of group 1 and 2 invest relatively similar shares into R&D as other world regions (approx. 0.5% of GDP, 2005-2015) (UNDP, 2018), while countries of group 3 fall again clearly behind.

d) Labour Market Flexibility

The EAME applied few regulations of the labour market and kept it highly flexible: Governments did not try to regulate the labour market via the introduction of unions, minimum wages, unemployment insurances or employment contracts. Unions in Korea were allowed on enterprise level only and generally weak and tightly controlled by the government until the late 1980s (Quibria, 2002). EAME reached high real wage growth rates without opting into strict protective labour legislation, increasing regulations and hence hindering companies in their efficiency. Page (1994) adds that boosting the demand for workers increased flexibility of labour markets. This facilitated to equalize the labour markets as well as wages between urban and rural markets.

Excessive regulation of the labour market, e.g. to protect workers, creates inflexible markets. Costs of labour are raised while demand for labour in the formal sector falls. Labour market regulations might incentivise rent-seeking behaviour of interest groups and unions as well as to segmentation of the labour market into covered and un-covered workers. Inflexibility of the labour market decreases its reaction opportunities to macroeconomic shocks as well as to new technologies and changes in the labour force. Lastly, investments can be rendered less profitable due to misallocated redistribution of rents (Quibria, 2002).

In SSA a highly discussed problem of the labour market, and restricting its efficiency as well as flexibility regards the informal sector. “Informal is Normal” in the region, as the informal sector provides a bulk of employment, while it is difficult to find high quality jobs in the formal sector (Fox & Gaal, 2008; Fox et al., 2017). This increases inequality and working within the informal sector is associated with lower wages, benefits and poverty (Woldemichael et al., 2017). Woldemichael et al., (2017) suggest further that especially the gap between rural and urban labour markets needs to be closed, as in particular the non-farm rural labour market lacks behind substantially.

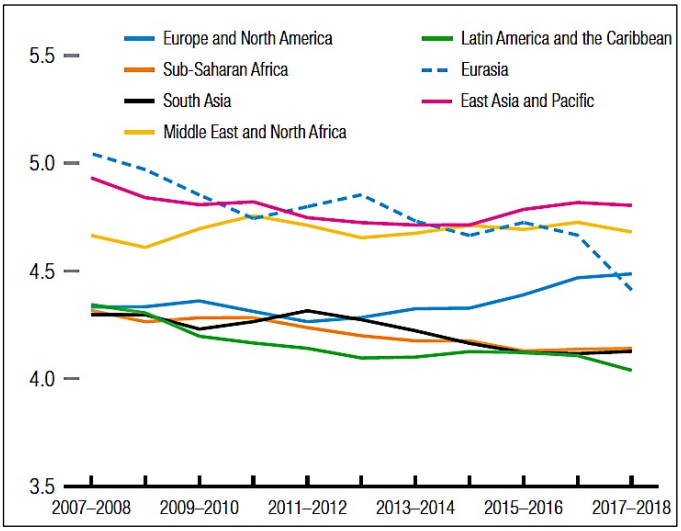

Figure 1 - Labour Flexibility Development, globally; Source: The Global Competitiveness Report 2017-2018.

Nevertheless, the GCR suggests that labour market flexibility and its efficiency is relatively high in SSA. Although overall labour market flexibility was generally decreasing during the last decade (Figure 1), this pattern needs to be differentiated. Second-best competitive countries (Group 2) clearly score above world average without SSA in terms of flexibility of the wage determination, while the other countries of SSA score similar to Eurasia, Latin America and Europe, and having higher flexibility than South Asia (WEF, 2018b) (Table 9).

Table 9 - Measures of labour market flexibility SSA, 2018

	Wage determination flexibility	**Labour market flexibility**
Group 1	4.67	4.59
Group 2	5.06	4.21
Group 3	4.45	4.01

Composition by author; data source: WEF (2018b).

This is in line with the *Labour regulation index* suggesting that SSA countries in general have an above mean market flexibility (Table 10). While the-most competitive country group in this index scores highest in flexibility (7.47) group 2 and 3 show a similar high market flexibility (6.4 and 6.1, respectively) (Vásquez & Porčnik, 2018). Similarly, labour market efficiency in group 1 is above world average and even above European level, while Group 2 is slightly less effective in its labour market than Europe and Eurasia (4.5 and 4.3 respectively). Group 3 (4.01) still clearly outperforms LA (3.8), South Asia (3.8) and the Middle East (3.8) in terms of labour market efficiency. Considering the efficiency of the labour markets in SSA countries as well as their relatively low labour market regulations, this condition seems to be fulfilled similarly as in EAME. All three groups are relatively homogenous and no extreme outliers are observable. In group 1 South Africa poses the lower end of flexibility, especially in hiring & firing regulations, whereas Senegal provides the least flexible labour market in group 2, and Uganda the group's most flexible country. In group 3 Nigeria and Swaziland have the flexibility while Mozambique, Madagascar and Angola show the most regulations.

Table 10 - Indicators of Labour regulation index, 2018

	Group 1	**Group 2**	**Group 3**
Hiring regulations and minimum wage	8,15	6,42	5,69
Hiring and firing regulations	4,92	4,71	4,39
Centralized collective bargaining	6,12	6,68	5,81
Hours Regulations	9,33	8,01	7,75
Mandated cost of worker dismissal	6,29	6,42	6,34
Conscription	10,00	6,39	6,38
Labor market regulations	7,47	6,40	6,06

Composition by author; data source: Vásquez & Porčnik (2018).

e) Institutional Framework & Quality of Governance

The governments of the EAME can generally be defined as autocratic but developmental states. This means that although autocratic in nature they were highly efficient, credible and predictable due to their powerful and technocratic bureaucracies and facilitated development of the economy. High standards in rule of law as seen by the importance of property rights as well as rather low and centralized corruption characterized the governments (Quibria, 2002). Centralized corruption has less adverse effects as relatively good resource allocation is reached through its centralized nature (Shleifer & Vishny, 1993). Additionally, the governments were highly accountable and committed to specific policies, developed by

economic councils and technocrat-led bureaus. This made the government decisions highly efficient and predictable over the long-run (Quibria, 2002; Page, 1994). Employing technocrats, building economic bureaus to ensure good economic strategies and stability as well as emphasising property rights, shows the EAME governments' focus on creating business-friendly environments to attract investments. Another focus was placed on shared and broad based growth, emphasised through political stability and support of and by the whole population: land reforms and wealth sharing programs were introduced as well as large scale government investments into infrastructure and education of the whole population undertaken in order to include large-scale population shares (Quibria, 2002). Generally, the economies were rated strong in country risk reports at their time of growth take-off: Korea scored 7/10, Singapore, Hong Kong, Taiwan 9/10 and Malaysia scored 6-7/10, only Indonesia falls behind in this relation scoring around 4 out of 10 (Quibria, 2002).

Generally, governments in SSA are rather instable and less predictable, coined by autocratic regimes, civil strife, weak and unresponsive institutions as well as corruption (Transparency International, 2017). However, Table 11 summarizes different indicators of the quality of the institutional framework and governance for the three groups of SSA countries and indicates that group 1 countries (Botswana, Kenya, Namibia, Rwanda and South Africa) are characterized by good institutions and enjoy good governance quality. They score in all categories and measures, besides 'favouritism in decision-making' above world average without SSA and e.g. in terms of corruption the group's score can be compared to some Western European countries, while the group outscores all other world regions besides Western Europe.

Nevertheless, group 1 poses 2 extreme outliers: firstly, Rwanda, scoring substantially higher in terms of public trust in politicians, corruption and favouritism in government decisions, and secondly, South Africa. South Africa sticks out negatively scoring significantly lower: in terms of corruption, public trust in politicians and favouritism in government decisions South Africa scores even lower than the average of group 3 countries.

Table 11 - Indicators institutional framework & good governance SSA, 2018

	Group 1	Group 2	Group 3	World average	Without SSA
Property rights	4,96	4,25	3,38	4,39	4,45
Intellectual property protection	4,60	3.88	3,30	4,17	4,24
Public trust in politicians	3,40	3.09	2,60	3,22	3,27
Ethics and corruption	3,84	3.17	2,74	3,68	3,77
Favouritism in decision-making	3,25	3.12	2,69	3,26	3,32
Transparency of policymaking	4,68	3.94	3,23	4,12	4,18
Government efficiency	4,23	3.64	3,00	3,64	3,66
Accountability	4,84	4.04	3,77	4,46	4,52
Institutions	4,38	3.77	3,29	4,04	4,10
Corruption (CPI)	48.00	37.36	28.38	43.07	43.44

Composition by author; data source: WEF (2018b). Transparency International (2017).

However, these countries seem to be the exception as suggested by data for countries of the other two country classifications. Both, countries of group 2 and 3 do not reach world average in any of the categories, this provides evidence of low institutional and governmental quality. Group 2 and group 3 countries show relative homogenous scores within the groups. Overall, while countries of group 1 fulfil the condition of good and effective institutions and reliable and predictable governments, all other countries of SSA do not.

3.1.2 Secondary Factors

Although not present in all EAME to the same extent a three secondary factors have been influential in the EAM, namely the extent of agricultural and structural transformation, high human capital and low inequality (Quibria, 2002). The *extent of agricultural (structural) transformation* is argued to have benefitted sustained growth by providing labour-force supply for the emerging manufacturing sector, due to increasing productivity and transformation of the agricultural sector (Page, 1994; Quibria, 2002). The EAME had strong and dynamic agricultural sectors experiencing rapid productivity rises, following the 'traditional path of structural transformation'. Figure 2 and Figure 3 compare the developments of sectorial value added and sectorial employment shares between 1st tier industrializer Korea, 2nd tier industrializer Malaysia and SSA. Comparing the three cases at the initial period of growth take-off, it is observable that recent manufacturing value added in SSA (taking 2000-2010) is at a similar starting level as in Malaysia and Korea, however contrary to the EAME the manufacturing value added to GDP is decreasing. Similar developments are seen taking the industrial value added. Further, the agricultural value added

is lower than in the EAME as well, while value added of services is at a higher level than when leapfrogging was started in Korea and Malaysia.

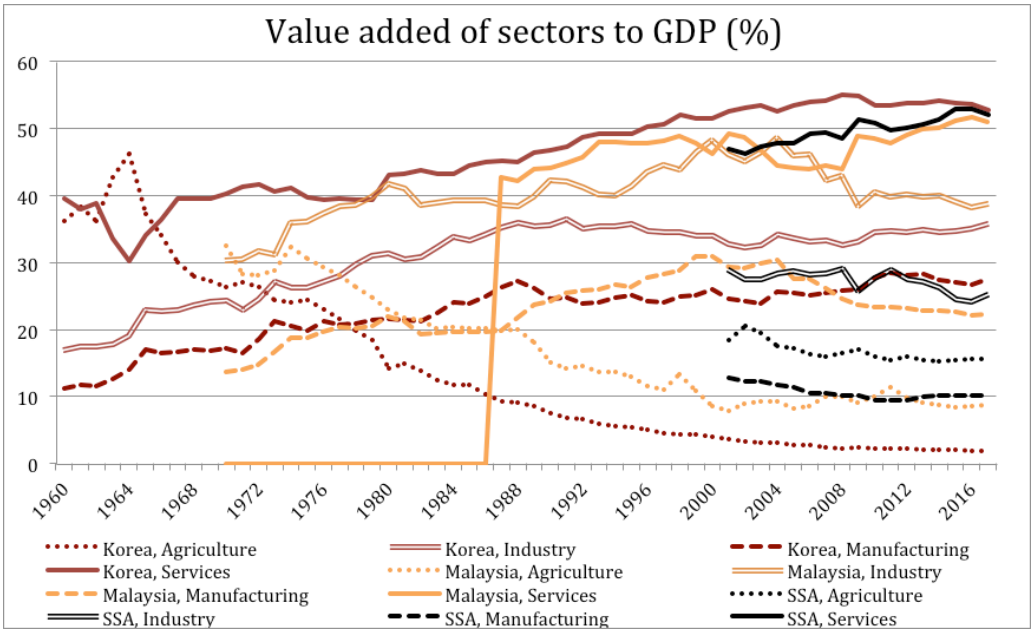

Figure 2 - Development of Value Added to GDP per sector, Korea, Malaysia, SSA; Construction by author; data source: World Bank (2018). Note: data for Malaysia prior to 1987 is missing due to lacking data availability in national accounts (World Bank, 2018)

Splitting SSA up into the three classifications following the GCR, the above trends apply as well (Figure 3). Manufacturing value added is low and slightly decreasing, while services provides the highest value and industry has about the same, decreasing, value added in all groups, agriculture has the second highest value added for group 3 countries.

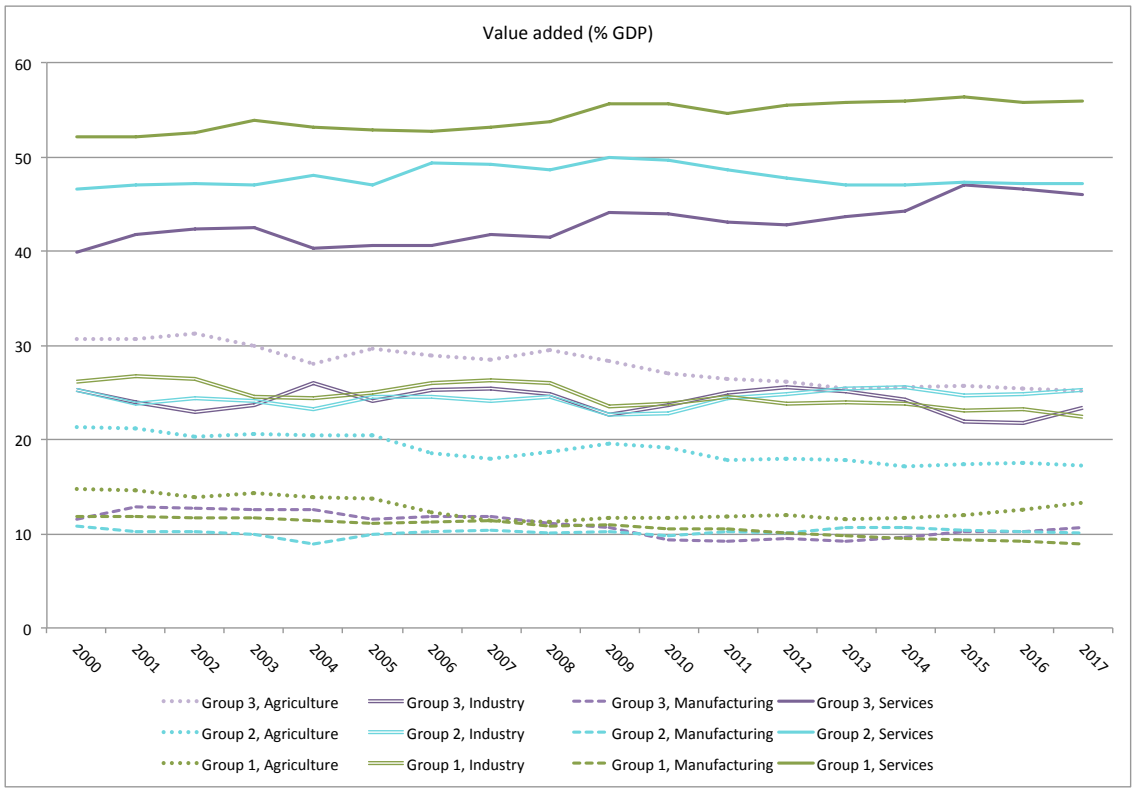

Figure 3 - Value Added to GDP per sector, SSA, 2000 - 2017; Composed by author; Source: World Bank (2018)

Combining this with data on sectorial employment developments it seems that agricultural and structural transformation are barely happening in SSA (Figure 4). Agricultural employment did not decrease considerably since 2009, while employment in the services and in particular the industrial sector are rather constant instead of being increasing, as it would be in case of the 'traditional structural transformation'. While the developments in levels seem to be slightly better with higher competitiveness and development, the differences between the three groups are neither substantial nor surprising. Services is the major employment sector for group 1 countries and probably soon in group 2 countries as well, whereas agriculture is the predominant sector in countries of group 3. Similarly, in group 1 industry employment is slightly higher than in the two other groups, however it is still the least employed sector.

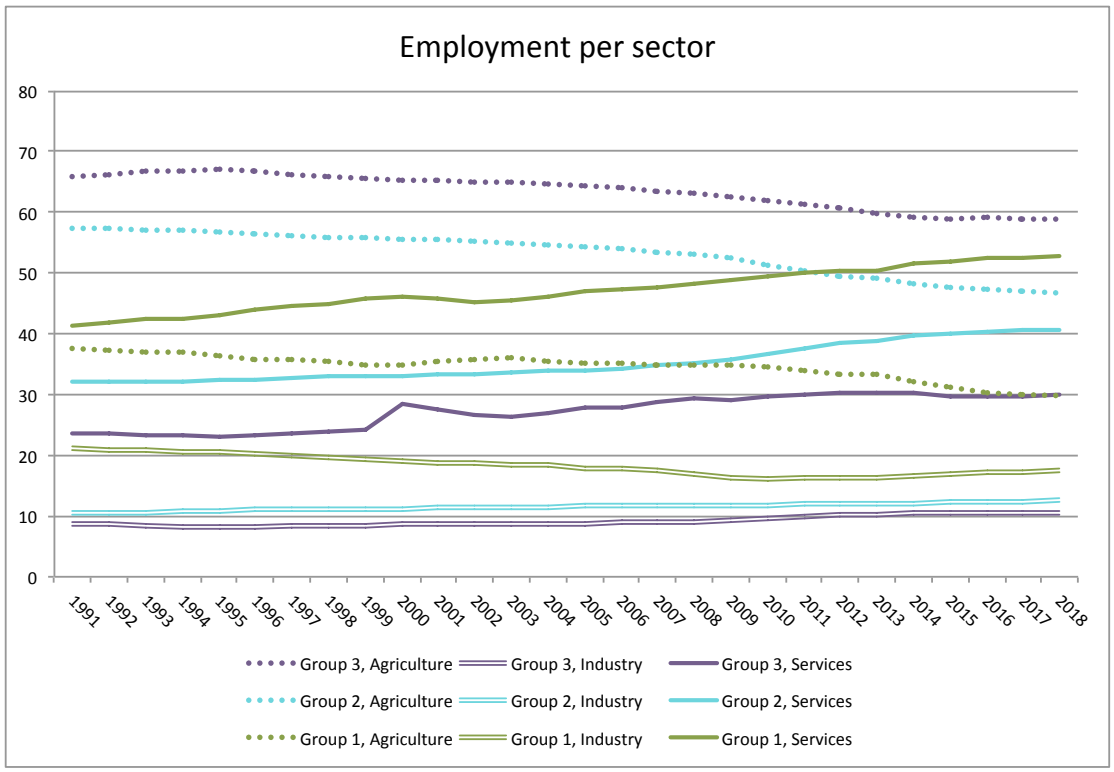

Figure 4 - Employment per sector, SSA, 1991 - 2018; Composition by author, data source: World Bank (2018)

Another highly important factor refers to *high human capital* and education of the whole population (Quibria, 2002). Especially in Korea and Taiwan high literacy and enrolment rates in primary and secondary education can be observed throughout the initial period of growth take-off, this was facilitated through prior Japanese rule. Differently, 2nd tier industrializers were left with low education levels of the vast majority of the population after colonial rule ended. However, they rapidly built an increasing educational base, with decreasing illiteracy as well as increasing enrolment rates as seen in Table 12. High human capital was important to increase productivity, adapt to new technologies and attract FDIs; additionally the capabilities of governments were influenced (Quibria, 2002; Page, 1994). The broad base of human capital in the population facilitated that the whole population participated in the structural transformation process and therefore in the growth process. Further, high returns to education were reached through the adaption of foreign technology.

Table 12 - Education Indicators, East Asian Miracle Economies & Sub-Saharan Africa

	Adult illiteracy	**Mean years of schooling**	**School Enrolment (% gross enrolment**				
			Primary		Secondary		Tertiary
East Asian Miracle (1st tier)	**1960**	**n.a.**	**1965**	**1995**	**1965**	**1995**	**1965**
Hong Kong	29.0	n.a.	103.0	94.0	29.0	73.0	5.0
Korea	29.0	n.a.	101.0	95.0	35.0	101.0	6.0
Singapore	46.2	n.a.	105.0	95.2	45.0	73.4	10.0
Taiwan	46.0	n.a.	67.0	99.1	37.0	88.8	n.a.
East Asian Miracle (2nd tier)	**1970**	**n.a.**	**1965**	**1995**	**1965**	**1995**	**1965**
Indonesia	43.7	n.a.	72.0	113.4	12.0	51.5	1.0
Malaysia	41.7	n.a.	90.0	104.0	28.0	59.0	2.0
Thailand	19.7	n.a.	78.0	87.0	14.0	54.0	2.0
SSA	**2018**	**2018**	**2000**	**2018**	**2000**	**2018**	**2000**
Group 1	15.5	7.68	106	113	57	78	5.5
Group 2	37.8	5.48	85	101	36	66	2.5
Group 3	43.8	4.68	86	105	23	42	3.5

Computation by author; data sources: Quibria (2002); UNDP (2019); World Bank Development Indicators (2019).

SSA still falls behind the other global regions in terms of HDI, measuring education, health and quality of life, however substantial improvements for all three groups are observable in Table 13. The different country groupings all increased the value of their HDI significantly by more than 0.1 index points each, during the last two decades (UNDP, 2019).

Table 13 - Life Expectancy, East Asian Miracle Economies & SSA countries, HDI SSA countries

	Life Expectancy		**HDI**	
East Asia	**1967**	**1997**	n.a	
Hong Kong	68	79	n.a	
Korea	58	72	n.a	
Singapore	66	76	n.a	
Taiwan	64	75	n.a	
Indonesia	46	65	n.a	
Malaysia	59	72	n.a	
Thailand	57	69	n.a	
SSA	**2000**	**2018**	**2000**	**2018**
Group 1	55	68	0.54	0.661
Group 2	55	64	0.45	0.560
Group 3	49	59	0.37	0.480

Computation by author; data sources: Quibria (2002); World Bank Indicators (2019) & UNDP (2019).

Similarly, life expectancy at birth rose from 50 to 55 years in 2000 to 60 to 68 in 2018 (World Bank, 2019). Therefore, although different among SSA countries, life expectancy today is in all SSA countries at similar levels as in the EAME during their growth take-off period (Table 12 & Table 13). While group 1 countries enjoy the same high life expectancy as Hong Kong (highest life expectancy of the EAME), even group 3 countries, which have the lowest life expectancy in SSA context, outscore the 2nd tier countries and Korea in life expectancy during the start of the growth trajectory. A lower-end outlier is observed in the case of Sierra Leone, which has only a life expectancy of 53, and hence scores lower than other group 3 countries. Similarly, Côte d'Ivoire sticks out negatively from group 2 with a life expectancy of 54 years. Mauritius is a positive outlier of group 1, as well as Cabo Verde and Seychelles of group 2, each indicating a considerably higher life expectancy of 73 years.

Concerning the knowledge and education part of human capital SSA countries, and in particular countries of the most competitive and developed group (group 1) score comparably well. Adult illiteracy in these countries is 15.5 % and is substantially lower than in all EAME in the respective periods. Countries of group 2 still outscore Singapore, Taiwan, Malaysia and Indonesia, while illiteracy in group 3 countries is about a similar level than in Indonesia and Malaysia when they started to leapfrog. A positive outlier is given by Seychelles, which provide for very low illiteracy (approx. 5%) compared to other group 2 countries. Negative

outliers from the group averages are Rwanda in group 1, showing significantly higher adult illiteracy; Ethiopia, Benin and Guinea in group 2 and Burkina Faso, Chad, Mali and Sierra Leone in group 3. In terms of mean years of schooling while group 3 countries fall substantially behind group 1 countries, all countries have higher mean years of schooling than e.g. 1st tier industrializer Korea (4.2 in 1960) as well as 2nd tier industrializers Indonesia (2.84 in 1970) and Malaysia (4.2 in 1970) (UNDP, 2019; World Bank, 2019). Again, Seychelles positively sticks out of group 2, providing for 9.5 mean years of schooling, while Guinea shows only 2.6 mean years of schooling and sticks out negatively from group 2. Similarly to illiteracy, Burkina Faso, Chad and Mali have considerably less years of schooling than other group 3 countries, while Rwanda has substantially less than other group 1 countries.

Additionally, school enrolment in primary, secondary and tertiary schooling increased significantly during the last two decades in all SSA countries (Table 12). Again, in particular countries of group 1 stand out positively, outscoring EAME data on school enrolment, especially and most importantly in tertiary education as well as secondary education. Furthermore, group 2 countries score in the upper midfield among the EAME, while group 3 countries still have relatively high enrolment rates for all three types of education compared to most EAME when leapfrogging started.

Lastly, low *income inequality* benefitted broad based economic growth and the participation and benefitting of the whole population, leading to the rapid and sustained economic growth. Massive land reforms prior to the growth periods in Korea and Taiwan facilitated the focus on shared growth and eased the path for sustained economic growth. Low inequality is resembled in low GINI coefficients: e.g. Korea had a Gini of 0.32 in 1961 and reduced it to 0.265 in 1966. Political stability and the population's support for the growth enhancing policies was secured through policies aiming at shared growth. Poverty at the lower distribution ends was reduced, while returns to investments of the higher parts of the distribution were ensured to foster economic growth (Page, 1994). Nevertheless, e.g. Malaysia's and Thailand's populations were less equal and Ginis hovered between 0.45 and 0.5.

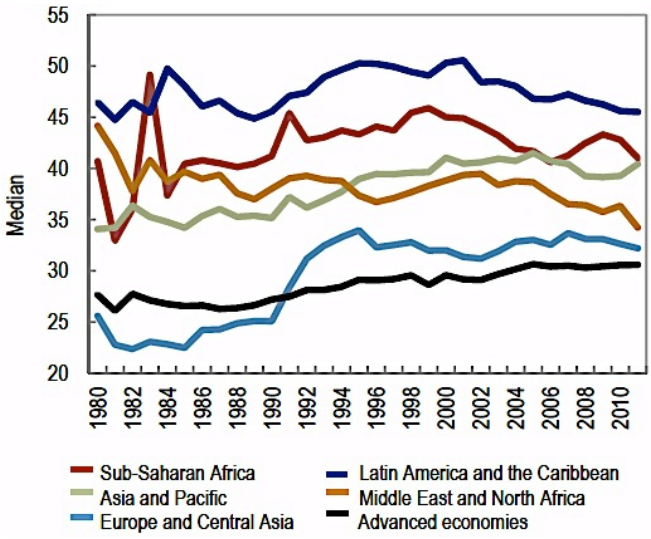

Figure 5 –Gini developments 1980 – 2010, globally; Source: Solt (2014).

SSA is argued to be one of the most unequal regions of the world after Latin America & the Caribbean (Figure 5): 10 out of the 19 most unequal countries are in SSA (UNDP, 2017). Although the region's average GINI decreased from 0.47 in 1991 to 0.43 in 2011, these developments are not necessarily encouraging as the last years of this period were characterized by rising inequality. This is supported by the fact that the group of the most development and most competitive countries has the highest average Gini (53.2) and comprises three countries with a Gini, higher than 60 (South Africa, Namibia, Botswana) (UNDP, 2019). These countries pose outliers not only to their group but also to the whole SSA region. This suggests that although some inequality was decreased, growth episodes are associated with increasing income inequality rather than substantial reductions. Group 2 and 3 countries are more homogenous, both within and between the groups, nevertheless, with Ginis of 42.8 and 41.8 respectively still experience considerable inequality however, significantly lower. Worrisome for these two groups however is that inequality concerns especially education and health, while income inequality is lower (Table 14). These income patterns are observable in the gap between the HDI and the inequality HDI, suggesting essential losses in human development due to inequality.

Table 14 - Inequality measures SSA, 2018

	Group 1	Group 2	Group 3
Gini	53.2	42.8	41.8
Inequality in income	42%	27%	26%
Inequality in education	22.8%	36%	35%
Inequality in life expectancy	19.1%	26%	33%
IHDI (HDI)	0.467	0.377	0.328
% loss in human development due to inequality	29.31%	30.1%	31.8%

Computation by author; data sources: UNDP (2017); (2018); (2019).

3.1.3 Truth Table

The above analysis has shown that firstly the three groups of SSA are highly heterogeneous in providing a basis for leapfrogging. Several of the conditions and factors enabling EAME to use leapfrogging as a strategy to use technological advance for sustained economic growth, are present in only one or two of the SSA country groupings, while other are present in all three. Table 15, in line with the research's QCA approach, summarizes the findings of the above analysis in a truth table. The results suggest that all primary factors are fulfilled in the countries of group 1 additionally, the secondary condition of relatively high human capital is given as well. Therefore, leapfrogging has a strong base and potential in these countries to translate technological advance from the 4th IR into economic growth. Countries in group 2 lack quality of the institutional framework and some openness to trade, nevertheless, all other primary factors are fulfilled as well as the condition of high human capital, thus although the potential might be smaller than in group 1 and more additional investments might be necessary, leapfrogging has a base in these countries too. However, countries of group 3 provide for a flexible labour market only and show high human capital relative to their development level. They lack institutional quality as well as macroeconomic stability and are not prepared to attract and absorb foreign, more sophisticated technology. These conditions make it difficult to apply the strategy of leapfrogging in the context, without investments to improve political and economic stability as well as openness of the countries for technology, businesses and investments.

Table 15 - Final Truth Table

Conditions/Factors	Group 1	Group 2	Group 3
Macroeconomic stability	1	1	0
Openness to trade	1	0	0
Openness to innovation & technology	1	1	0
Labour market flexibility	1	1	1
Institutional framework & Governance quality	1	0	0
Agricultural (Structural) transformation	0	0	0
Human Capital	1	1	1
Income Inequality	0	0	0

Composition by Author, adapted and following Ragin (1987).

The next section sets these results into the context of the 21st century by interrelating the results with the changed external conditions as well as to current developments and processes in the context of the 4th IR. Additionally, it shows possible challenges and ends with suggesting policy recommendations.

3.2 Discussion

In order to examine the implications of the results of the above-pursued analysis and to explore what this means in relation to economic growth for SSA, this discussion puts the results into the context of current developments in SSA as well as relating them to reports and media coverage of the topic. Although positive as well as negative outliers exist, this research aims at providing a concise and more general overview and it would be beyond this research's scope to discuss country-specific results. While being aware of the outliers and the region's as well as the sub-groups' heterogeneity, the following section provides a more general discussion along the lines of the GCI ratings.

3.2.1 Implications of results

The above analysis shows that the countries scoring higher in development and competiveness have a sound basis to apply the strategy of leapfrogging to technological advances of the 4th IR in order to boost economic growth. Taking into account factors and conditions which enabled the EAME to use leapfrogging as a strategy for economic growth, Botswana, Kenya, Mauritius, Namibia, Rwanda and South Africa have high potential to employ the strategy of technological leapfrogging to enhance economic growth through the 4th IR. Recent processes and developments are in line with this result and show that leapfrogging is already taking place.

A widely known example of technological leapfrogging, M-Pesa, refers to mobile banking. It was initiated in Kenya in 2007, and already spread to various countries in SSA today (Bates Ramirez, 2018). Additionally, M-pesa was extended in Kenya by M-kopa, which is a pioneering technological breakthrough and provides solar energy on a pay-as-you-go scheme. Payments are done, similarly to M-pesa, via the mobile phone and millions of rural Kenyans, without connection to the electricity grid, are provided with off-grid green energy and electricity (M-kopa, 2019; Matthews & Lee, 2018). Similar developments are observable in Rwanda were solar energy can be bought through a prepaid system at solar kiosks. These green off-grid energy and electricity possibilities provide the rural population in SSA with the opportunity to study at night, charge phones and participate in development. Moreover, productivity of the population is raised through higher capacity-building possibilities and increased work flexibility. Innovation and technological leapfrogging in the context of the 4th IR in these countries is not limited to financial services, mobile phones or the energy sector: In Rwanda, blood transfers can be delivered by drones (World Bank, 2017) while in South Africa robotic pharmacy systems increased the capacities of the country's busiest HIV clinic and reduced errors and the waiting times significantly (Bates Ramirez, 2018).

These examples of current, on-going leapfrogging developments in the more advanced and competitive countries of SSA show that these countries are not only successful in path-skipping leapfrogging, as for example skipping land-line telephones by directly adopting mobile phone technology. Rather, they embarked on a path-creating leapfrogging approach and are forerunners in the extended use of mobile phones, as well as in the use of robotic technique in the health sector.

Countries, such as Benin, Cameroon, Cape Verde, Ethiopia, Gabon, Gambia, Ghana, Guinea, Senegal, Seychelles, Tanzania, Uganda and Zambia are less competitive than the first group and face difficulties mainly in relation to their institutional framework and seem to be less open towards international trade. However, openness to international trade seems less important in the context of the 4th IR. Emerging technologies as robotics and AI advances, are argued to lead to the automation of low-skill industry jobs and ultimately the re-orientation of western companies from low-cost workers abroad to automated production closer to the consumer (Schwab, 2016; Cilliers, 2018). This decreases the importance of global value chains and international trade, while re-emphasizing regional trade and regional integration (Cilliers, 2018). Therefore, although these countries' potential might be smaller and the base for leapfrogging not as strong as in the first group, leapfrogging is still feasible in the second group of countries to use technological advances from the 4th IR to enhance economic growth.

In line with this, it can be observed that most of these countries embarked a path-skipping leapfrogging approach. For example following Kenya in adopting the technology of M-pesa for mobile banking, or off-grid green energy solutions, group 2 countries such as Tanzania, Ghana and Côte d'Ivoire clearly leapfrogged development stages in the sphere of electricity and energy supply from no or insufficient grid-supply to green off-grid energy provision (Salty, 2018). Nevertheless, fulfilling most of the conditions from the EAM, and providing for relatively high and widespread human capital as seen in the analysis before, these countries show some potential for path-creating leapfrogging as well by not only absorbing but building technological advances and creating innovations (Heinrich-Böll-Stiftung, 2018). This can be seen in Cameroon, where a tablet was developed to be used for heart examination in rural areas of the country (Diop, 2017).

Lastly, the analysis showed that the least competitive and advanced countries of SSA, Angola, Burkina Faso, Burundi, Chad, Democratic Republic of Congo, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Nigeria, Sierra Leone, Swaziland and Zimbabwe face great difficulties in building a basis for successful technological leapfrogging. The GCR argues that the macroeconomic environment and its stability are of utmost importance for competitiveness and that continued deterioration of macroeconomics was the main driver of falling competitiveness and growth during recent years (WEF, 2018a). This relates to this research's results showing that countries with higher macroeconomic stability have a higher potential and better base for technological leapfrogging. Nevertheless, Maharajh (2018) points

out that even in the least developed countries of SSA, the creativity for creating technological advances and innovations is prevalent (Heinrich-Böll Stiftung, 2018). Additionally, the relatively high level of human capital, compared to EAME at the starting point of their growth trajectory, can possibly benefit the least developed countries in the future. This promotes building a more business and investment friendly environment in these economies, if other conditions are improved. Interestingly, all three groups seem not able to fulfil the extent of agricultural and structural transformation towards manufacturing, which was experienced in the EAME. However, taking into account the changed international circumstances, transformation into manufacturing does not seem as important and beneficial as during the EAM. This is in line with Rodrik (2014) as well as Ghani and O'Connell (2014) arguing that economic development today is not necessarily dependent on building a strong manufacturing sector.

Hence, leapfrogging as a strategy is applicable and already used to benefit from technological advances of the 4th IR in some countries in SSA. However, although already applied, it seems to be difficult to translate technological leapfrogging into sustainable economic growth in SSA: "for all the hype about leapfrogging […] growth rates rarely reached the sustained double-digit levels" of the EAM" (Pilling, 2018). Although building a strong manufacturing sector is less necessary and even possibly harmful for SSA in the context of the 4th IR and the current international setting (Tan, 2018), it plays a role in accompanying and translating technological leapfrogging into economic growth. Calestous Juma (2018) points out that although technological innovation is a main driver of economic growth, the success of it depends on infrastructure and industrial capacity, which are both built through industrialization. Thus, not every factor of industrialization and structural transformation can be leapfrogged.

These findings are in line with opinions about SSA's growth trajectories and mirrored current developments. Many SSA countries provide a good or even strong base for technological leapfrogging, are open towards new and foreign technology and increasingly have the capacities to adopt the new technologies as well as the creativity for creating their own innovations (Heinrich-Böll-Stiftung, 2018). Nevertheless, the infrastructure to efficiently use and spread the technology to the population of the countries (region) is lacking. Therefore, missing infrastructure is the biggest obstacle in the successful translation of technological leapfrogging to economic growth (KPMG, n.d.). This can be observed in various examples in

SSA. Technology-based solutions as for example apps which improve the markets' transparency, provide support in price-setting or decision making on which crops are most efficient to plant and have the potential to increase productivity of the agricultural sector in SSA. However, poor quality and lacking quantity of transportation infrastructure, missing refrigeration and the absence of irrigation as well as fertilizers vanish the effect of this potential. Knowing the most efficient crop to sow or which market price to ask for does not increase productivity if the crops rot before reaching the market. In Kenya and Ethiopia only 44% and 32% of the rural population, respectively, live within 2 km to an all-season road. Similarly, using AI and tablets for doctor consultations helps only to a certain extent to overcome shortcomings in the health sector. These technological advances do not solve the problem of the lack of doctors and hospitals or the inaccessibility of doctors in rural areas (Pilling, 2018).

Bill Gates (2018) further argues that technology cannot be a substitute for good governance, and processes in less advanced countries having inferior institutions and instable governments suggest that some countries are "too badly organised or too busy lining their own pockets to provide decent healthcare for their people" (Pilling, 2018). Additionally, while highly sophisticated technology is used for doctor's consultations via streamed videos in rural areas, no clean running water is available in the very same place (Pilling, 2018). This suggests that there are limits to technological leapfrogging brought by a mismatch between technological advance and basic industrial capacity and infrastructure in the region. Technology might provide the possibility for sustained economic growth and brings services, capabilities and infrastructural improvements to SSA, however the successful absorption and efficient use of it depends on infrastructure and good governance.

Therefore, this research's results relate to the concepts outlined in the theoretical framework. Technology is a main driver of economic growth and technological leapfrogging is applicable in the case of SSA. However, it is also observed that social capabilities and initial conditions matter, as leapfrogged technology needs to be absorbed, scaled-up and spread to translate into economic growth. In particular, the provision of good infrastructure is important in this relation in order to efficiently use technological advances and to connect and include the population with and in these advances in order to enhance economic growth. Further, this discussion provides evidence that the quality of the institutional framework as well as the governance plays an important role not only in the applicability of technological leapfrogging

but for the successful translation of technological advances into economic growth. The higher the countries score on governmental factors and macroeconomic stability measures, the higher their potential for innovation and path-creating leapfrogging exists.

Thus the results imply possible challenges of technological leapfrogging into the 4th IR in SSA. Next to the challenge and the related problems of lacking infrastructure and governmental instability, high inequality in the region poses a problem. This problem is not only faced by the least advanced and competitive countries, but countries such as South Africa, who otherwise provide a strong basis for technological leapfrogging and shows successful processes of leapfrogging, experience it as well. High inequality hinders the essential scaling-up of technology and bears the risk of excluding large shares of the population from the growth process. Successfully sustained economic growth requires a large share of the population participating in the growth trajectory. Only a broad good-skilled labour force can successfully absorb and apply leapfrogged technology, as seen in the EAM. The problem of inequality is especially problematic in the course of the 4th IR, as inequality within the countries of SSA, between the countries of SSA and globally could be substantially increased through technological advances and economic growth for some but not all (Schwab, 2016).

Although linked to inequality, another challenge on its own refers to the growing population of Africa. SSA enjoys the world's largest untapped workforce potential, taking into account dependency ratios and future developments of the African population, implying decreasing birth rates and a growing workforce. This can be a window of opportunity, but only if the potential can be unlocked and the mismatch between the amounts of talent and possibilities to work productively can be solved. Otherwise, increasing poverty and inequality as well as falling further back and even missing out on the 4th IR could be the consequence for SSA countries (Osotimehin, 2015; Schwab, 2016).

3.2.2 Policy Implications

Following the discussion of the results, relating them to current developments and outlining possible challenges in the process of technological leapfrogging in the 4th IR in SSA and its translation into economic growth, the results yield ground for policy implications.

Given the decisive point in time posed by the 4th IR being either a window of opportunity or bearing the risk of falling further behind on-going investments in all SSA countries should be pursued in order to either remain competitive (group 1 countries) or to become (more) competitive (all SSA countries). Considering the analysis above and the mismatch between technological possibilities and lacking infrastructure, investments into infrastructural improvements and connectivity within and between the countries is of utmost importance. Improving transport infrastructure would raise agricultural productivity in particular as technological advances in terms of sowing and market transparency could be used to a larger extent. Moreover, improved infrastructure increases the attractiveness of SSA countries for businesses to settle and invest, which would enhance economic growth itself. In connection to this it is important to particularly support the less competitive and advanced SSA countries in stabilizing their macro-economic and governance structures, in order to increase competitiveness and enable them to attract investments themselves.

Considering the immense amount of young people in SSA and the potential implied by this, investing in young people and human development is of utmost importance to ensure the creation of a broad and skilled labour-force to unlock the potential of the interplay of immense population growth and the 4th IR. In this relation investments concerning "education, health, including sexual and reproductive health, skills training, job creation, and equality for women and girls" seem most beneficial and growth enhancing. By doing so SSA could add about $500 billion to its economies annually for a period of 30 years (WEF, 2015).

Additionally, the importance of regional integration is rising in relation to the 4th IR (Schwab, 2016; Cilliers, 2018). Regional integration is a topic already experiencing raised awareness in SSA in terms of trade and trade-related infrastructure. Nevertheless, extending regional integration and cooperation to spheres of education, health and deepening regional collaboration in infrastructural projects could imply highly beneficial outcomes, especially in the context of the 4th IR. With increased regional integration, less advanced SSA economies could also benefit from their 'forerunners', by adapting similar policies and investment-decisions. By doing so, SSA could follow the EAM in building several tiers of economic growth, building on each other and ultimately including today's least competitive countries in the economic growth trajectory.

4 Conclusion

This research set out to analyse the applicability of technological leapfrogging to the case of SSA in the context of the 4th Industrial Revolution. It did so by firstly analysing whether a base for technological leapfrogging is given in SSA and secondly by discussing how technological leapfrogging in the course of the 4th IR is translated into economic growth in SSA. Argued to be both a window of opportunity for catching-up as well as a curse, bearing the risk of falling further behind, the 4th IR is said to pose a decisive point in time on developing and developed economies. The research accounted for the heterogeneity of the region by dividing the region's countries into three groups following the widely accepted and known global competitive index developed by the World Economic Forum. Further, this study adapted a qualitative comparative analysis approach based on a specific set of factors from the successful example of technological leapfrogging in the EAM, which were analysed and explained amongst others by Quibria (2002) and Page (1994).

This research finds that the more competitive and advanced countries provide a strong basis for technological leapfrogging. The first group of countries fulfils the five primary factors of macroeconomic stability, openness to trade, openness to innovation & technology, labour market flexibility and good governance and a solid institutional framework. In addition, the analysis shows that human capital is relatively high in these countries providing for path-creating leapfrogging. The second group lacks some openness to trade and some governance quality, however still provides a basis for technological leapfrogging, albeit more path-skipping. The group of least competitive and advanced countries shows substantial back draws and does not provide a basis for technological leapfrogging similar to the one in the EAME or the other two groups of SSA countries.

Recent developments support these results. The most competitive countries, providing the strongest basis for technological leapfrogging are innovating and technological advancing, using the novelties of the 4th IR. As seen in the discussion of the results, they embark path-creating leapfrogging processes by leading other countries in technological innovations in e.g. the health or off-grid green energy sectors. Given a weaker base, in particular through lower

performances in institutional and macroeconomic indicators, technological leapfrogging turns into path-skipping technological advances until it vanishes, when the base is not provided for anymore.

Thus, this research concludes that technological leapfrogging is not only possible and feasible in SSA to use the 4th IR for economic growth but that it is already applied in some countries. Nevertheless, it proves further that although some factors as for example openness to trade turned less important in this relation, openness to innovation, state capacity as well as macroeconomic stability are of utmost importance in initiating the process and for translating technological leapfrogging into economic growth. Additionally, this research argues that good infrastructure is highly important in the relation between technological leapfrogging and economic growth. As seen in various recent examples even in the most competitive countries, a mismatch emerged between technology and infrastructure. This mismatch hampers the successful translation of technological change into sustainable economic growth. Further, it has shown that high inequality of the region poses a challenge for long run sustainable growth as remaining high inequality could possibly exclude parts of the population from participating in the growth process.

Therefore overall, social capabilities, initial institutions as well as infrastructure are highly important and could in the end be the driving factor for successful translation technological advances from the 4th IR into sustainable economic growth in SSA. The potential to use the 4th IR through leapfrogging is given in most of the countries and investments and projects can support countries, which partly lack the base for leapfrogging until now. As seen in this research's extended analysis, some SSA countries already embarked path-creating leapfrogging strategies and hence show potential to even lead technologies in the 4th IR, as e.g. green off-grid energies or technological advances in the health sector. Nevertheless, as seen during the EAM, the growth process would need to be accompanied by further investments and efforts to include the growing population and to build a strong state capacity as well as to keep the economies stable in order to remain competitive. Similarly, investments would be necessary to keep the level of human capital, increase it and spread it throughout the population in order to reduce inequality and to include the broad population into the labour force.

Ultimately, this study yields interesting policy implication to enable the whole region to apply technological leapfrogging to embark an economic growth process as well as to improve the

translation of technological leapfrogging into sustainable economic growth. Namely, investing in sound business- and investment-friendly circumstances to equip the least competitive countries with the necessary base for technological leapfrogging; solving the mismatch between technology and infrastructure by increasing infrastructural quality as well as investing in particular in the young people in the whole region in order to improve translation of technological advances into growth. Additionally, similar to the EAM, the growth process should be complemented by efforts to increase equality, state capacity as well as economic stability and competitiveness constantly.

Further research should thus be done on specific investments into regional as well as local infrastructural improvement to translate already happening technological leapfrogging more successfully into economic growth. Investments and projects to support and accompany the process of economic growth and technological leapfrogging, following the EAM example, should be formulated and prepared. How to raise these investments and how development aid could be sustainably used to support in particular the least competitive and advanced countries to build an investment and business friendly environment by stabilizing the economy as well as improving their state capacity are related questions of high importance to use the window of opportunity provided by the 4th IR successfully in SSA.

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Appendix A

A.1. Grouping of the countries of Sub-Saharan Africa, following ratings in the Global Competitiveness Report (WEF, 2018).

Group 1	**Group 2**	**Group 3**	**Missing**
Botswana	Benin	Angola	Central African Republic
Kenya	Cameroon	Burkina Faso	Republic Congo
Mauritius	Cape Verde	Burundi	Comoros
Namibia	Ethiopia	Chad	Equatorial-Guinea
Rwanda	Gabon	Democratic Republic of Congo	Eritrea
South Africa	Gambia	Lesotho	Guinea-Bissau
	Ghana	Liberia	Niger
	Guinea	Madagascar	Sao Tomé & Principe
	Senegal	Malawi	Somalia
	Seychelles	Mali	Sudan
	Tanzania	Mauritania	South Sudan
	Uganda	Mozambique	Togo
	Zambia	Nigeria	
		Sierra Leone	
		Swaziland	
		Zimbabwe	