Can Rwanda leapfrog to the digital economy with ICT enabled development?
A case study of a developing country determined to modernize without the traditional model

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Abstract: Proclaiming the successful way forward for Africa to modernize continues to puzzle economists and policy makers. Though the region has experienced the highest growth rates for the past decade, no large-scale structural transformation can be observed. Africa’s continuous failure to industrialize has shown that the conventional model of a country experiencing an agricultural transformation and the related traditional industrialization, through creation of a manufacturing sector, has been disrupted. However, technological advancements, mainly ICT, have made the service sector more productive, and globally ICT is one of the fastest growing sectors. This paper looks into the development of Rwanda, a low-income country, on its path of becoming a service-oriented knowledge-based economy without experiencing agricultural productivity growth and the following industrialization. As the ICT sector combines economic activity in both services and industry, but also has fundamentally transformed the way economies operate, the study finds that as innovations constantly spur from ICT and the definition and the limits of the sector continue to adapt, it is too early to tell if long-term growth can be sustained and development achieved. However, the development in modern countries confirm that economic activities increasingly concentrate around the knowledge economy and as such investments in skills and infrastructure for the new business opportunities are necessary.

Key words: ICT, services, structural transformation, developing country

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1 Introduction

Proclaiming the successful way forward for Africa to modernize has been puzzling economists and policy makers for decades, and though currently many of the highest growth rates are experienced on the continent, no large-scale structural transformation has been seen. Africa’s continuous failure to industrialize has shown that the conventional model of a country experiencing an agricultural transformation and the related traditional industrialization through creation of a manufacturing sector has been disrupted. Recently Stiglitz (2017), an economist and Nobel laureate, a professor at Colombia University and World Bank chief economist from 1997 to 2000, stated, that “services, not manufacturing, will be the growth sector for Africa”.

Additionally, already from 2014 the African countries have committed to invest heavily in the enabling and strategic role of Information and Communication Technology (ICT) for the rapid transformation of Africa, which is clearly stated by the Chairman of the Smart Africa Board, President of Rwanda, Paul Kagame, for the Transform Africa Summit in April 2018:

“The next decade 2016-2025 promises to be the decade of Africa’s development through ICT. … the foundation of this initiative, is based on 5 principles: To put ICT at the center of our national socio-economic development agenda; To improve access to ICT especially Broadband; To improve accountability, efficiency and openness through ICT; To put the Private Sector First; To leverage ICT to promote sustainable development.

The creation of Smart Africa is a testimony of our resolve to put in place the right policy and regulatory environment that will encourage partnerships, entrepreneurship, job creation and knowledge sharing. Our move towards an ICT and knowledge driven economy together intends to increase Africa’s competitiveness in the global economy. ICTs have the ability to level the global playing field, unlock human capital and harness its full potential.

The Smart Africa Board is committed to lead this transformative agenda in our respective countries. Our goals are ambitious yet realistic and with our leadership, commitment, strategic work and support from our partners, I am fully confident that we will soon achieve our vision of modern economies and wealthy citizen that will lead to a prosperous future for Africa.” (Smart Africa, 2018)

Moreover, a major change in development strategies for Africa launched in April 2018 by the World Bank and International Finance Corporation (IFC) could ignite a spark for the long-awaited excitement and hope for the future of Africa. The new strategy is to give support for the creation of “digital economies” and to promote digital skills, as the World Bank believes
Africa can leapfrog past the traditional way of developing by the higher uptake of technologies and will follow in the footsteps of countries as China and India, who have been able to tap into the capitalization of the constantly growing interactions online (Devex, 2018).

The spread of technologies has opened up new markets, created jobs and increased efficiency, but PWC, a global consulting company (2016), found that especially digital connectivity is central to these developments, as it increases the availability of goods and services but also decreases the challenges of distance and allows for knowledge transfers, so increasing innovations. World Bank’s strategy has been questioned as currently Africa is still the region with the lowest connectivity, especially when it comes to internet access (ITU, 2016), and betting on the digital economy to transform Africa seems unlikely. However, the main argument of World Bank is that as the rest of the world is making use of the rapidly expanding and developing technologies, Africa cannot afford to further distance itself from other countries by yet again falling behind. Although the “new model” of digitalization has not been confirmed to work on its own, success stories from other countries in the past, such as the East Asian Miracle, prove that there is not just one path to development.

Several studies have suggested different development models for Africa. Stiglitz (2017) offers a multifaceted inclusive growth strategy, which replaces the success factors of manufacturing-led export growth with a learning-led growth, as he believes Asia’s model cannot be replicated in the future. More conventionally, the African Transformation Report 2017 (ACET, 2017) suggests that it will be modern agriculture in combination with labor-intensive light-manufacturing for exports, such as agro-processing, which will power industrial transformation. While the latest African Economic Outlook (AfDB, OECD & UNDP, 2017) notes that manufacturing will not be in the center of development policies, industrialization is still the main strategy to promote inclusive economic transformation. Though the report mentions that new technology offers a potential for growth in services, the skill gap between Africa and the rest is substantial, and so the sector is not a probable engine of growth. Oppositely, Ghani and O’Connell (2014) are optimistic that services could be growth escalator in low-income countries due to the third industrial revolution of digitalization, which has altered the sector fundamentally, but also blurred the lines between services and manufacturing. However, the region’s own enthusiasm and belief in ICT enabled development and leapfrogging envisioned by the World Bank and IFC could refer to a new model, which differs from the traditional path of employment moving from agriculture to industry and finally to services.

Exploring the new model of engaging directly in the third industrial revolution of digitalization is a significant area of research as it could help understand better which policies the still developing countries should emphasize and what are the thresholds for success. The effects of ICT have been researched more within the developed world, one reason being the lower diffusion in the developing countries. The current thesis discusses the developments experienced in Rwanda, a low-income non-resource rich developing country in the heart of Africa, on its path to modernization without having experienced a structural transformation through increase in agricultural productivity and expansion of the industrial sector. The country is of specific interest as already since 2000 Rwanda has been certain of its investments in ICT and secured ICT’s role as a crosscutting issue in its long-term development policies. Moreover, the World Economic Forum (2015, cited in MiTEC, 2017)
ranked Rwanda as 1st globally in ICT promotion. This thesis looks into the role of ICT to transform a poor country like Rwanda, and the possible new model for Africa to catch up with the rest of the world.

1.1 Country Background

Rwanda is a landlocked country in East Africa with a strong drive to modernize and become a knowledge-based service-oriented country. Though the country is one of the smallest in Africa, it is among the ones with the highest population density, and, as is the case with most African countries, bursts with the amount of young people, with 40.5% of population under 15 years of age in 2016 (WDI, 2018). The capital province, Kigali City, is clearly the most urbanized and densely populated with 76% living in urban areas, while 70% of population still lives in rural areas (NISR, 2012; WDI, 2018).

Rwanda has experienced a turbulent past, resulting in the genocide against of 1994, where nearly a million people were killed. The genocide was ended by, then rebel forces, current ruling political party RPF (Rwanda Patriotic Front) and its President Paul Kagame. After the genocide the country fell into ruins as the loss of lives and destruction of economic activity plunged the country into poverty. Though the country is still mostly remembered for its past, for over a decade Rwanda has been one of Africa’s most strongly growing countries accompanied with a growing reputation of being safe, well-governed and politically stable. In 2010 Rwanda was ranked as “the world’s top reformer” by the World Bank’s Doing Business Report (World Bank, 2010), and in 2017 Rwanda was second out of continent meaning that the regulatory environment is more conducive to the starting and operation of a local firm (World Bank, 2018). In 2016 Rwanda placed as third least corrupt country in Sub-Sahara Africa, though still far from higher ranked countries (Transparency International, 2018). Rwanda’s GDP has been rapidly increasing since 2001 as seen in figure 1.1, but already after the genocide, from 1995, growth has averaged around 8% annually (WDI, 2018).

![Figure 1.1 GDP (current US$), in millions, in Rwanda, 1960-2016 (WDI, 2018)](image-url)
Moreover, Rwanda has been successful with social development, as the country has been able to fulfill many of the United Nations Millenium Development Goals in 2015, including targets such as gender equality, women empowerment, universal primary education, child and maternal mortality, HIV prevalence, and environmental sustainability. Life expectancy increased substantially from 48.4 years in 2000 to 67.1 years in 2016 (WDI, 2018). These achievements have proven the government’s ability to adopt the international recommendations into its own long-term development policies and also indicated the interventions to be effective. Hence, in 2015 Rwanda was ranked globally as seventh among the most efficient governments (WEF, 2014). However, it is questionable whether the success is due to a thriving economy as Rwanda is heavily dependent on foreign aid.

Consequently, Rwanda also categorizes as one of World Bank’s 31 low-income countries with a $700 GNI per capita (in 2018 low-income economies are defined as those with a GNI per capita, calculated using the World Bank Atlas method, of $1,005 or less in 2016) (WDI, 2018). Though GDP per capita has experienced an average growth rate of around 5% after the genocide, the rate is slower than GDP growth as population growth has simultaneously been strong. Additionally, Rwanda is still one of the 47 countries categorized as least developed (LDCs), characterized by the following three criteria by (UNCTAD, 2018):

1. Per capita income (gross national income per capita)
2. Human assets (indicators of nutrition, health, school enrolment and literacy)
3. Economic vulnerability (indicators of natural and trade-related shocks, physical and economic exposure to shocks, and smallness and remoteness).

These 47 countries, which experience immense structural challenges to growth, contain around 880 million people, equivalent to 12% of the world population. Still the contribution of the LDCs to the world markets is minimal, as they account for less than 2% of world GDP and around 1% of world trade (UNCTAD, 2018). The majority of the LDCs are located in Sub-Saharan Africa as seen from figure 1.2.

Figure 1.2 Least Developed Countries (LDCs) in 2017 (UNCTAD, 2018)
1.1.1 Visions for the Future

Rwandan Government has aligned its long-term development agenda in the Vision 2020, a strategy that seeks to transform the country from a low-income, agriculture-based economy to a knowledge-based, service-oriented economy with middle-income country status by 2020. The Millennium Development Goals defined by the United Nations were central to the framework policies. (Republic of Rwanda, 2012)

Table 1.1 Pillars of the Vision 2020 and its crosscutting areas (Republic of Rwanda, 2012)

<table>
<thead>
<tr>
<th>Pillars of the Vision 2020</th>
<th>Cross-cutting areas of Vision 2020</th>
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<td>1. Good governance and a capable state</td>
<td>1. Gender equality</td>
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<tr>
<td>2. Human resource development and a knowledge-based economy</td>
<td>2. Protection of environment and sustainable resource management</td>
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<tr>
<td>3. A private sector-led economy</td>
<td>3. Science and technology, including ICT</td>
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<td>4. Infrastructure development</td>
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<td>5. Productive and market-oriented agriculture</td>
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<tr>
<td>6. Regional and international economic integration</td>
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These six pillars were chosen in order to tackle the economic and social development challenges Rwanda faces and to prepare for the future. The major objectives of the development strategy are macroeconomic stability and wealth creation to reduce aid dependency, structural economic transformation and creating a productive middle class and fostering entrepreneurship (Republic of Rwanda, 2012). All the objectives are interlinked, as with the support of entrepreneurship and private sector development the diversification of the economy and creation of a middle class can be achieved, as though agriculture could be transformed into high value and productivity sector, it is not enough to function as the engine of growth. Other sectors need to be nurtured, though service is seen as the most important in terms of growth. All in all, infrastructure combined with improvements in education was seen necessary in order to have a globally competitive economy.

To support the long-term development the medium-term strategies, EDPRS1 and EDPRS2 were also formed. The first Economic Growth, Poverty Reduction and Human Development Strategy covered the period 2008 to 2012 and the second 2013 to 2018. The EDPRS2 aims to target areas, which will ensure that Rwanda will achieve a middle-income status by sustaining high GPD growth, reduce poverty and restructure the economy towards services and industry.
EDPRS2 has four thematic areas: economic transformation, rural development, productivity and youth employment, and accountable governance (MINECOFIN, 2013).

Though the long-term strategy areas target the economy as a whole, in order for Rwanda to become a service-oriented knowledge-based economy ICT was integrated as a crosscutting issue in the Vision 2020 and as a central priority in EDPRS2 after the increased use of ICT solutions was found to improve service delivery (MINECOFIN, 2013). ICT is noted especially within productivity and youth employment creation, but also in rural development with improved infrastructure, including ICT expansion, connecting rural communities with economic opportunities (Republic of Rwanda, 2012). Globally ICT sector has been increasing its share of contribution to GDP growth and proven to create new profitable markets, which also developing countries can tap into. Rwanda aims to capitalize on its new reputation as a country with high ranking on ease of doing business, continually increasing investments flowing in and enabling the vision of becoming a hub for financial, ICT, transport and logistic services in the region (World Bank, 2017).

To ensure that development challenges are addressed and Rwanda’s growth towards becoming a knowledge-based economy is accelerated, Rwanda deployed the National Information and Communication Infrastructure (NICI) Plans, first of the five-year plans incepted in 2000, which base on the policy of ICT for development (ICT4D) adopted already in 1998 and targets the increased utilization of ICT from government to individual level (MiTEC, 2017). The NICI’s focused on creating a conducive legal and regulatory framework, infrastructure development matching global levels and the utilization of ICT infrastructure, including the development of service and private sectors (MiTEC, 2017). After NICI III, the five-year plan was renamed as the Smart Rwanda Master Plan (SRMP), with a focus on innovation as the use of ICTs to enable a transformation towards a digital economy generating growth and job creation. The ambitious visions are described in detail in the following:

Establishing a Service-oriented, Modern, Accountable, and Real-Time (SMART) Government that drives Rwanda’s global competitiveness and job creation; Becoming a highly competitive, agile, open and innovative smart economy with the most favorable business climate that attracts large-scale investments, rewards entrepreneurship and enables fast growth and exports; and leveraging powerful ICT innovations such as Digital solutions, Internet of Things, Big Data and Analytics, Creative Industries and Multimedia, Mobility & Digital Lifestyle, Robotics, Block Chain, Artificial Intelligence and e-commerce. (MiTEC, 2017)

The most recently derived ICT Sector Strategic Plan (ICT SSP) for 2018-2024 will complement and expand the SRMP and other national development plans, and focuses on Economic, Social and Governance transformation leading to an even faster achievement of socio-economic change (MiTEC, 2017). According to the Ministry of Information Technology and Communications (MiTEC), which was separated from Ministry of Youth and ICT (MYICT) in the past few years, “the ICT sector shall continue to be a catalyst for rapid and sustained economic growth, equitable social development and employment creation” (MiTEC, 2017, p.4).
1.2 Research Problem

Since 2000, Rwanda has made significant progress with massive infrastructure projects shaping the country, together with strong urbanization, constant high growth rates and foreign direct investment flowing in. The emphasis is now on ICT to transform the economy. As indicated previously, the skills gap and low diffusion of ICT in Africa might affect the productivity gains received from ICT and hinder the growth of service sector. Additionally, as Rwanda’s visions for rapid growth are ambitious, such as joining the fourth industrial revolution in areas such as the Internet of Things (IoT), robotics, artificial intelligence (AI), understanding the sought development model and its implications is necessary. As ICTs affect all sectors of the economy, it is intriguing to learn if the country is just applying a new general-purpose technology (GPT) and upgrading all of its sectors at once to catch up or truly leapfrogging. Rwanda is often used as a model country for development in African context, and as the application of ICT has been emphasized in the long-term development strategy it might portray a way forward as a forerunner.

1.3 Aim and Objectives

The aim of the study is to examine the development model of Rwanda by looking into the disruptive impacts of ICT as a general-purpose technology but also as a sector. The study presents the main modern growth and development theories and then reflects to the developmental challenges experienced in Africa. In addition, the expectations of ICT diffusion and impact on the economy are discussed through relevant literature. As it is generally stated that Africa lags behind the rest of the world, the objective is to analyze if current technological advancements could enable Rwanda to leapfrog and catch up with the rest. As ICTs have been widely diffused since 1990s and Rwanda’s Vision 2020 was deployed in 2000, the data period is set for 2000 to 2016. Rwanda’s development is contrasted mainly to the continent but figures for developing countries are used in order to demonstrate the vast existing gap. However, ICT permeates various sectors and invites innovation, but is also being continuously updated, which brings up a challenge for measuring the impacts. Hence, this study pursues to answer the following question:

1. Has prioritizing ICT enabled development in Rwanda in 2000-2016?

The question is studied by taking various aspects of the economy into consideration, such as looking into the features of the economy, ICT sector policies, ICT diffusion, education and labor markets. The findings portraying Rwanda’s ICT sector growth and ICT development are then analyzed in the light of previously discussed development models and literature. Finally, the ICT enabled development model is discussed in detail.
1.4 Outline of the Thesis

This thesis analyses the developments experienced in Rwanda with an emphasis on ICT and is organized in the following manner. Chapter 2 presents theory and previous research on modern growth and development, and the challenges of Africa experiencing structural transformation through industrialization. The chapter also presents the concept of leapfrogging with ICT, in addition to presenting Rwanda’s past development. Chapter 3 explains the methods and data used, outlining data relevance and data constraints. Chapter 4 lays out the main findings of ICT development in Rwanda and strives to answer the research question. Chapter 5 concludes to propose areas for future research in order to examine the model of ICT enabled development for the continent.
2 Literature and Theoretical Review

The following literature review presents the development theories, with an emphasis to industrialization and discusses the relation to the past and current situation of Africa. The section then presents the impact of ICT as a general-purpose technology and how its effect on Africa has been reviewed in the recent discussion. Finally, the section presents the development and structural change in Rwanda.

2.1 Growth and Development Theories

Countries experience different paths to development but are often distinguished between their incomes. Economic growth, the increase in per capita income, depends on two processes, the accumulation of assets (such as increasing the size of the capital, labor, and land), and making those assets more productive (Perkins et al. 2013, p.14,64). However, economic growth does not consider if the growth is due to incomes concentrated on the hands of a few or distributed evenly, and as such high growth due to a sudden discovery of a natural resource such as mineral or oil might lead to an increase in growth but does not lead to development as the majority continue to live in a traditional society (Perkins et al. 2013, p.20). Hence, an overall increase in incomes of the population, which leads to improving human welfare, such as health and education, but also to major structural changes as industrialization and urbanization, is defined as economic development (Perkins et al. 2013, p.20). What is not protested, but historically and globally not ed, that long-run economic growth tends to be a fundamental determinant of human welfare, though it is still not fully understood which factors assure growth (Perkins et al. 2013, p.90).

Economic development has been reached through structural transformation, which is the movement of employment from agriculture to industry and finally to services. This movement increases incomes as labor moves from low-productivity sector, agriculture, to higher productivity sector, industry and services (Lewis, 1954). During this phase of economic growth inequality first increases but gradually becomes less unequal as the country modernizes (Kuznets, 1955). Agriculture dominates as the biggest employment sector and share of value added of GDP in many low-income countries (Perkins et al. 2013, p.584,587). Agriculture is unproductive due to the labor surplus, especially in developing economies with large subsistence farming. However, labor force leaving to other sectors will eventually make it more productive, so increasing wages (Lewis, 1954). Agricultural productivity is desirable as an increase in agriculture’s share of GDP strongly affects poverty reduction and food security in comparison to an increase in non-agriculture (Perkins et al. 2013, p.618; Dercon & Gollin, 2014, p.13; Christiaensen, Demery & Kuhl, 2011, p.3).
Today’s developed countries experienced structural transformation through industrialization and by creating a manufacturing sector. According to Lewis (1954) the movement from agriculture to manufacturing is beneficial for the labor worker due to the higher and generally fixed wages in manufacturing. The higher incomes increased the savings to income ratio and growth tends to become self-sustaining above a certain critical level of income per capita. Lewis also adds that economic development is increased with the rapid capital accumulation together with knowledge and skills.

However, in order for an economy to establish modern industries, government intervention was seen necessary, and the “big push” theory of Rosenstein-Rodan from 1943 became popular (Perkins et al. 2013, p.132). The theory claimed that to reach self-generating and cumulative growth, large investments developing wide range of industries at the same time, fixing the needs at once within infrastructure and economically productive sectors, will generate growth. He argued that small investments spread across the economy will not make a difference to a stagnant economy, one reason being that the domestic markets needed to be there before any industry could succeed, and so people were employed in newly built factories and receive higher incomes in order to buy the products from the other factories. As these investments need to be large it was the government’s responsibility to organize, which made planning very much supported.

In 1950s and 1960s development economics agreed generally that development derives from structural transformation and that after a certain amount of per capita income growth will be self-sustaining, as savings ratio would increase (Killick, 1980). As industrialization at the time had proven a successful engine of growth, it was seen mandatory, and for a few decades focus was on import substitution in manufacturing. Import substitution with strong government planning was enforced in South America, though as the domestic markets small size the growth slowed down in the (Perkins et al. 2013, p.136-138). At the time development was seen strongly dependent on high growth rates, which did not always benefit the whole population and was in need to be steered to ensure distribution, which brought up the challenge of government intervening in markets, favoring certain industries (Cooper, 1981). Later, structural adjustment reforms such as the Washington consensus freeing the market and having less government intervention were seen recommendable (Perkins et al. 2013, p.145).

The East Asian Miracle was a major shift from import substitution discovering an alternative manufacturing-led export growth model, which rapidly increased GDP per capita and standards of living (Perkins et al. 2013, p.141-142). Since their success this has been as a recipe for other countries to achieve rapid growth in a short period of time. However, the power of manufacturing seems to not have delivered same promises in low-income countries, such as Africa (Ghani & O’Connell, 2014). The following section discusses the growth and development models suggested to Africa, and the options to modernize without manufacturing-led growth.
2.2 Growth and Development Model for Africa

Strategies to increase growth and transform Africa have varied as can be seen from Cooper’s (1981) compilation of recommendations:

Some experts recommend industrialization, others agricultural development; some encourage commercial farmers to increase the scale of their operations, while others favor peasants; some look to the growth of a modern sector that draws resources from backward sectors, while others stress rural self-sufficiency or else the value of an urban informal sector; and still others have stripped away all accretions to the market model of the economy which is the underlying basis of this school, arguing that Africans will do best if the market is left alone.

Though the high growth rates observed in Africa could have been expected to transform the countries, many have stagnated economic sectors, and no or negative productivity increase in agriculture. Additionally, as service sector experiences the main growth, the majority is still employed in agriculture and are the ones in need of an agricultural transformation as this results in major poverty reduction. Currently, services represent the highest value added share in Africa with 58.1% (WDI, 2018), while a sort of deindustrialization, reduction of manufacturing’s share of GDP, could be found ongoing for some decades (Rodrik, 2014; Subramanian 2014, cited in Ghani & O’Connell, 2014).

The growth has apparently originated from elsewhere than a structural transformation, such as commodity booms increasing export value or post-war catch-up, such as investments in building and other infrastructure. The low performance of African countries after independence in the 1960s, was criticized to originate from the high emphasis set on creating a higher GDP but not on the distribution of the benefits of the GDP (Perkins et al. 2013, p.137). Violence is prone to increase in a country with greater inequality, Sub-Saharan Africa not being an exemption (Bourguignon, 2004, p.19) Moreover, inequality leading to political instability might affect investment levels hindering creation of industries (Alesina and Perotti, 1996, cited in Bourguignon, 2004, p.19).

Lack of modern growth and structural change is also explained by the adverse institutions, which persist from exploitative colonial times. According to Acemoglu and Robinson (2010), Sub-Saharan Africa’s political and economic institutions cause weak states, where insecure property rights cause lack of incentives, such as population saving and investing, which results in low supply of public goods by the government. Also, they continue, that low interest of colonizers to develop the continent hindered human capital attainment, low-skill level was sufficient for primary product exports. When industrialization could have been seized within the newly independent countries, the education level and infrastructure were insufficient (Austin, 2010), which led to a path dependency of authoritarianism, continuous economic decline and poverty (Acemoglu & Robinson, 2010).

Though industrialization through manufacturing has not yet been successful, strong arguments support the conventional model that modernization cannot be reached without industrialization and having manufacturing as an important factor. In order to start
industrialization, agricultural productivity needs to increase, which has been a challenge in Africa. Africa as most low-income economies have exports dominated by natural resources and commodities, and as the prices are volatile stable growth process is hard to obtain or eventually ineffective to lead to economic development (eds. Andersson & Axelsson, 2016, ch.4, p.10-11; Perkins et al. 2013, p.687). Additionally, Austin (2008a) argues that factor endowments, such as environmental constraints as geography and thin soil, low population density and low-skilled technology have prevented the agricultural productivity increase before, making structural change costly.

However, the latest African Transformation Report 2017 (ACET, 2017) argues that agriculture needs to become even more emphasized as it will have the greatest effect to the whole economy, suggesting that increasing productivity and output will improve food security and allow fewer imports but more exports of food products, but most importantly will also sustain agro-processing, the manufacturing of agricultural inputs and the linkages to different services, creating jobs and increasing incomes. The opinion of the African transformation report is that Africa has the possibility to pursue a dual-track to industrialization, which are complementary and reinforce each other: a track which leverages the regions agriculture to become globally competitive in agriculturally based manufacturing, and another track, which is labor-intensive export-oriented light-manufacturing. Though Dercon and Gollin (2014) doubt the agriculture-led transformation in Africa, but they similarly argue for more of a balance between investments on agriculture and industry.

Having agriculture in the center of the economy is different to the earlier suggestions related to manufacturing-led growth. Inspired by the East Asian success, Lin (2011) suggested African countries to follow the flying-geese pattern in order to seize the opportunity provided by the industrial upgrading of China and other leading dragons. Lin argued that the model where late-developers industrialize by starting production in simple goods freed by more industrialized countries and upgrading along the production line towards more sophisticated ones, is feasible if economies develop industries according to their comparative advantage and tap the potential of backwardness.

However, Rodrik (2014) finds that developing countries starting manufacturing industries will face much greater challenges today than the Asian countries did before. One being the change in global economies as developing countries are expected to follow stricter regulations in trade and production affecting subsidies, local-content requirements and copying of patented products. Second, manufacturing itself has changed, technological changes have made it more capital- and skill-intensive, and so not absorbing unskilled labor as it used to before, but also there is inability to begin protected domestic markets due to global competition of very highly productive and cheap Chinese and other Asian imports. This Finally, today’s industries will be under much higher scrutiny for pollution and environmental concerns can harm the natural comparative advantage of a country.

But as argued by Stiglitz (2017), all that was done in one sector to boost exports cannot be done anymore and that Africa cannot repeat East Asian miracle, mainly because though emerging countries have taken shares of the manufacturing sector from Asia and jobs have been moving from China to Africa, the sector is not able to absorb the new entrants of the labor force, also as the productivity has become higher than demands, partly because of
automation. However, the East Asian Miracle was due to investments in infrastructure, rapid skills development and technology diffusion (Krugman, 1994), and though growth through manufacturing would not be repeated, these one-time investments can still be beneficial in Africa, as all areas score lower than in anywhere else in the world. Though the source of growth would differ, also Rodrik (2014) finds that policies for growth shared by successful countries will continue to include “a stable macroeconomic framework; incentives for economic restructuring and diversification (both market-led and government provided); social policies to address inequality and exclusion; continued investments in human capital and skills; and a strengthening of regulatory, legal, and political institutions over time”.

Though Stiglitz (2017) was quoted as promoting services for the future of Africa, he does actually propose a combined sector strategy of learning-led growth, which will have a degree of openness, the constraint awareness and take inequality into account. The new model of the coordinated strategy of agriculture, manufacturing, mining and service sector, will create the same benefits, which were delivered by manufacturing-led exports, such as providing basis for learning and demand for educated individuals, collecting tax revenues for government investments as infrastructure and education, which cannot be received from the large informal sectors, but also creating urban jobs for the new entrants, while being economically profitable. Stiglitz points that in the new structural transformation towards a modern economy of modern services, the government will play an important role.

Additionally, Stiglitz (2017) agrees with the views of African Transformation Report 2017, that emphasizing agriculture is a necessary as most people reside in rural areas but realizes the challenges of commodity exports not resulting in sufficient investments on other parts of the economy, but the countries dependent on the export have continuously been hit hard after the boom returns to bust. Also, he reminds that low-skilled manufacturing may result with a race to the bottom and believes that manufacturing should be more directed and limited, taking advantage of natural resources such as minerals, but pushing towards more complex products. A similar approach is offered in the Least Developed Country Report 2014 (UNCTAD, 2014), where a major shift in LDC policies towards more sophisticated and higher-value added products is proposed, though mineral exporters had not experienced any or low structural transformation. This again invites to study the opportunities of services being the inclusive growth sector in the future.

Rodrik (2014) had found some aspects of manufacturing in the service sector, as likewise to manufacturing certain service sectors such as food and clothing retail services have made good use of new technologies, absorb lower skilled labor, but also create links with the domestic economy. He concluded that if these service branches were able to have productivity convergence, these could possibly be growth escalators. To support Rodrik’s statement, Ghani and O’Connell (2014) found in their study that growth convergence in service labor productivity between developed and developing countries was similar but steeper than manufacturing, and so developing countries could benefit from faster catch up and stronger growth of services. However, Duarte and Restuccia (2010, cited in McMillan & Harttgen, 2014) argue the opposite, that productivity differences in services has remained significantly lower in developing countries relative to the rich, while productivity in agriculture and industry have substantially narrowed, and so developing countries with high growth rates have typically reallocated labor to high-productivity manufacturing.
Though McMillan & Harttgen (2014) disapprove the idea of growth through service sector, as they argue that services are an unlikely engine of sustained productivity growth over the long run, and so entrust that industrialization via manufacturing will move from China to Africa. While Ghani and O’Connell (2014) were open to the impact of services, their reasoning did not also oppose manufacturing, but saw that if services will not provide growth Africa and the rest non-industrialized countries need to wait for China, the manufacturing powerhouse of the world, to become richer and uncompetitive before the sector would move onwards to the low-cost countries. However, a few years later Stiglitz (2017) sees that industrializing through manufacturing, following a similar path as East Asia, will not at all be possible for Africa.

The success stories of service sector as engine of growth are often seen as atypical, such as found also in McMillan and Harttgen’s (2014) study where structural change in Mauritius was found to be driven by highly productive service sector, absorbing labor and increasing growth, and while manufacturing had earlier been a significant sector for growth, its share had been declining. Agriculture and mining were seen insignificant. Though they continue to argue that industrialization is necessary, the current situation shows that manufacturing in large-scale still hasn’t begun to move from China to Africa, but that services continues to increase its share in Africa.

Technological progress alters the economic activities, such as automation making manufacturing more capital and skill intensive, so creating less jobs. The latest disruptive technological advancement of ICTs has just lately been more diffused around Africa, though the impact has been evident in the developed countries. The following section discusses the impact of ICTs more in detail.

2.3 ICT as General-Purpose Technology (GPT) and a Growth Sector

Though ICTs consist of a broad range of products and services, the concept is seen as a new general-purpose technology (GPT) as it fundamentally transforms the organization of a wide range of economic activities but also affects the daily lives of individuals. Bresnahan and Trajtenberg (1995, cited in Rousseau, 2006, p.120-121) define a GPT by the following three characteristics:

1. Pervasiveness: the GPT should spread to most sectors.
2. Improvement: the GPT should get better over time and, hence, should keep lowering the costs of its users.
3. Innovation-spawning: the GPT should make it easier to invent and produce new products or processes.

ICTs have enabled rapid change and productivity growth in the same way, as did the GPTs steam engine, electricity and combustion engine in the past (Rousseau, 2006, p.118). ICTs arrival, a period often called the third industrial revolution, could be placed around 1960-70s with the introduction of the key component of the personal computer (Rousseau, 2006,
However, the ICT revolution heightened in the 90s and ICT prices fell comparatively faster and to a lower point of purchase than earlier GPT’s as electricity, though it is noteworthy to mention that electricity has not become obsolete, but that ICT is very dependent on electricity (Rousseau, 2006, p. 136). ICTs permeate various sectors of the economy from banking to education to health but were noticed to being more slowly adopted than electricity, possibly due to the increased competition and rapidly falling prices of electronics, and as such firms waiting to update their capital with the lowest possible price (Jovanovic and Rousseau, 2002a, cited in Rousseau, 2006, p.135). David (1991, cited in Rousseau, 2006, p.119) noted, that neither electricity nor ICT increased productivity growth directly after their invention, though it was found that after the launch of each technology economic innovations such as patents, initial public offerings (IPOs) and investments experienced an increase (Rousseau, 2006, p. 135). However, ICTs have contributed more to further innovation than electricity (Rousseau, 2006, p.135), and as the diffusion of ICT is still ongoing with advancements to the technology constantly happening, investment in ICT is to improve efficiency and increase growth potentials.

In the case of services, ICTs have transformed the sector fundamentally, such as allowing services to be produced and traded similar to goods but also facilitating trade, as digital services have lowered the cost of trade, also avoiding many logistical barriers and customs (AfDB, OECD & UNDP, 2017; Bhagwati, 1984, cited in Ghani & O’Connell, 2014). Also, productivity in the sector has increased as technology and innovations have increased links between supply chains and services, especially within the modern services as transport, finance and telecommunications (Ghani & O’Connell, 2014). However, services consist of a large variety of jobs and different wage levels, and similarly do not guarantee a move to higher incomes. Ghani and O’Connell (2014) found that growth in services require investments in various areas, such as physical infrastructure, especially in communication and transport, human capital as skills and education, entrepreneurship and trade connectivity.

Innovations such as the ICTs have brought along new economic activities and in order to correctly calculate and compare the economic activities between countries the fourth revision International Standard Industrial Classification of All Economic Activities (ISIC) (UN DESA, 2008) introduced new high-level categories, “Information and communication” being one such new section in 2008. Information and communication combines the following service sector activities: Publishing activities, Motion picture, video and television programme production, sound recording and music publishing activities, Programming and broadcasting activities, Telecommunications, Computer programming, consultancy and related activities, and Information service activities. These splits within sectors were made, as the fourth revision of the ISIC states that by the time of writing the report, Telecommunications was globally one of the fastest growing activities, and for policy purposes the division is necessary. Though it is acknowledged that there is and will continue to be a challenge to set boundaries between telecommunications, broadcasting, Internet and IT services, in addition to new technological developments, as all are interlinked.

However, Information and Communication sector does not represent the ICTs in total, as though the communication between people has been reformed resulting in many new services, but also the actual technology behind the services and how we operate in this new sector has changed. As described, the current phenomena of growing information economy comprises of
elements, which cross over existing high-level ISIC categories but also over the broad economic sectors of agriculture, industry and service. Though standard groupings are necessary, the ICTs have had a revolutionary effect in economies and become of interest to statisticians, economists and policy makers. In order to reach correct figures, ISIC created an additional alternative aggregation, the Information and Communication Technology (ICT) sector, which includes activities from a wide range of sections, spreading out to manufacturing, trade and services, see appendix A (UN DESA, 2008). The ICT sector consists of activities, such as manufacturing, wholesale and repair of computers and communications equipment, telecommunications, software publishing, computer programming and data processing. The possibly most commonly known applications are computer and internet.

ICT’s effect on economic growth has been analyzed by many and it is commonly agreed that ICTs create productivity and innovation across all sectors of the economy. Currently, ICTs foster innovation with over 30% of all patent applications filed in ICT technologies, and the sector has been growing constantly in the OECD since 2003, resulting in 5.4% of GDP value added in 2015 (OECD, 2017). The share of value added in telecommunication services and in computer and electronics manufacturing has decreased in the OECD, while growth is gradually driven by software production and services (OECD, 2017). Similarly, UNCTAD (2007) concluded that the productivity gains in developing countries have been caused by the growing ICT sector, rather than the actual use of ICT, which is the case in developed countries. Accordingly, OECD (2017) notes that suitable skills are needed for effective use of ICTs in work and life, and that in addition to specialist skills, the constantly adapting work environment requires problem solving and communication skills, which are currently insufficient among workers who use ICT. In 2015, ICT sector in OECD accounted for 4% of total employment (OECD, 2017).

Even though, technology might have reduced the possibility of manufacturing entering the African continent, it has created other jobs, as the predictions of job losses resulting from technology have not happened. However, the new jobs in technology require higher human capital. Despite the evident skill gap, use of ICT is predicted to offer the still developing countries a chance to catch up with leapfrogging. But are the countries ready to exploit this opportunity or can there be too much of economic backwardness?

2.4 ICT Enabling Leapfrogging in Africa

Globally another industrial revolution is spreading with IoT and AI, while the African continent has been left behind, barely transformed in the earlier revolutions. There is a risk that if the current revolution is not being joined that Africa will be left too far behind and will face even greater challenges as the rest of the world adopts and diffuses new technologies increasing their competitiveness. Though as presented before, it is often agreed that modernization cannot happen without industrialization. However, this exact process might currently be happening in Africa.
The increasing penetration of mobile phones, expansion of 4G networks and more Africans online have created successful innovations such as the internationally spread mobile banking Kenyan M-Pesa, making Africa the world leader in mobile money. These innovations have created high enthusiasm for technology to rapidly transform the continent and to leapfrog more advanced economies. Leapfrogging is here described as skipping a step in development due to innovation, such as the diffusion of mobile phone avoiding the investment of installing fixed-phone networks. It can be argued that as there are no institutions in place yet, there is less barriers to adopt these new technologies and so more space for innovation.

The leapfrogging theory is often referred to China as governmental policies were used to sponsor industries with production of high-tech and high domestic value-added products, which would otherwise not have been natural to promote (Wang, Wei & Wong, 2010). These goods as exported would bring higher value than producing according to the country’s own comparative advantage. The study notes that high values of FDI with technology diffusion could suggest leapfrogging. Though in the case of China ease of doing business was not high, high FDI amounts were received due to building of special industrial parks, which lowered the barriers to entry and contributed to the creation of technology hubs (Lin, 2011). When relating this to Africa similarities are found, as the IFC (2018a) believes that the high-tech start-ups help Africa leapfrog developmental challenges, as is portrayed in a recent article on Kenya’s tech-entrepreneurs. The article finds that entrepreneurship is growing and that the spirit is high as technological breakthroughs and successful digital solutions are found to assist Africa’s development, such as the mobile banking platform, M-Pesa, which made financial services available to the majority of the population, connecting even the rural parts of the country. The article notes that it is the technological spillovers, entrepreneur-driven innovation and environmental and sustainability concerns, which disrupt the traditional way of technology diffusion, and allow the developing countries to skip steps in development and to achieve rapid progress.

ICT could be a solution to modernization as various positive benefits can be found, such as internet enabling economic growth by providing increased access to information, connecting people and businesses and creating and opening up new markets. A study by Deloitte (2014) found that extending internet access to levels similar of the developed countries, developing countries in Africa, Latin America, India and South and East Asia could increase productivity as much as 25 %, create 140 million new jobs and increase incomes, so lifting people out of poverty. Additionally, human capital growth within education would be supported with the increased access to information. The report sees that developing countries will be able to benefit from the knowledge economy, now not needing to build infrastructure, which previously hindered their progress.

However, though largely behind of the developed countries, in some areas Africa is catching up. In example mobile phone usage experienced a 344 % growth from 2007 to 2016, which translates to a staggering 772 million, a remarkable amount of the 1,2 billion total population (ITU, 2018a). Internet availability is the main challenge, currently mobile broadband is estimated at 30 % in Africa, while 43 % are connected in Asia, in addition to only 15 % of Africans having internet at home (ITU, 2018a). Positively, a recent IFC report (2018b) expects Africa’s consumption growth to increase between 2014-2030, and spending on ICT was projected as second highest sector, just after transport. Rwanda would be among the
countries with highest household consumption growth in most sectors, ICT experiencing third highest growth in spending. Though PWC (2016) finds that the devices used to connect to the internet are relatively old, and so limit the access to available content, this might change in the near future due to consumption growth.

The report by Deloitte (2014) also mentions that it will be the small and medium sized enterprises (SMEs) which will benefit the most from access to internet as barriers to entry become lower and the challenge of distance and connection to clients disappears. As small firms or own account workers, often within informal service markets, largely characterize the developing countries, digitalization could also help bring the informal sector into the mainstream economy in example through mobile banking (PWC, 2016).

Leapfrogging is also discussed here as more than the diffusion of technological innovations in order to skip the need of installing old technology, it is also seen as a term for avoiding the need of following the traditional path to modernization through manufacturing. Leapfrogging development stages can be seen supported by Gerschenkron’s (Gunnarsson, 2016) economic backwardness, government intervention could substitute prerequisites for industrial growth such as late developers could import technology in order to industrialize without having agricultural productivity. Moreover, farming is currently not seen as an occupational option within the African youth, and the average age of a farmer is estimated as high as 60 years, which further challenges the productivity growth in the sector (ACET, 2017). However, Calestous (2017) argues that industrialization itself however, cannot be leapfrogged as no other advanced country has done that before, and that infrastructure is necessary for industrialization, but also for the basis of technological innovation. He also reminds that as services are closely linked to the industrial sector, building a local manufacturing is necessary as it brings investments in infrastructure and talents as engineering. He continues to argue, that the mobile revolutions ability to stimulate industrial development and diversification has failed, as the continent is now a consumer not a producer of technology, but that the path could still be changed if industrialization would be set back on the development agenda.

As manufacturing following the East Asian model was challenged in the previous sections, some suggest the upcoming Fourth Industrial Revolution would open new opportunities for Africa due to the its lack of legacy, such as 3D printing customized manufacturing, which would revolutionize the Asian successful manufacturing with lower investment in machinery and need of higher and creative skills (PWC, 2016). Also, Naudé (forthcoming, cited in AfDB, OECD & UNDP, 2017) states that the following three major technologies of the current Fourth Industrial revolution impact Africa’s revolution: i) robotics, automation and artificial intelligence; ii) additive manufacturing (e.g. 3D-printing) and iii) the Industrial Internet and data analytics. He continues that services have become more important, which promotes industrialization with more sectors than just manufacturing.

However, Naudé notes, that the fourth industrial revolution differs from prior industrial breakthroughs, as it requires more high skilled workers, while ICT tends to replace medium and low skilled ones. Moreover, general skill gap is a great challenge in Africa. Brookings (2018) estimates that in terms of how many years of school an average student attends and how much she learns, it will take an average student in Sub-Saharan Africa almost 100 years to catch up to the average student in high-income countries. However, they are optimistic that
as innovation is already strong, and existing technology is used in new ways to solve problems, the educational gap could be leapfrogged with technology. In addition to the enormous gap in knowledge, Stiglitz (2017) notes that the other main challenge, is in lack of resources. IFC (2018a) adds that the tech-entrepreneurs face challenges with insufficient infrastructure, unreliable electricity and connectivity but also limited funding.

2.5 Chapter Summary

Though manufacturing has been the reliable engine of growth for many countries in the past, especially for Africa it has not taken off. As described above, there is support for ICT enabled long-term growth, and as some researchers have suggested ICT could assist in the catch up of Africa and other low-income countries through leapfrogging. Consequently, it could be assumed that since cost of ICT has decreased the diffusion would be largescale and as ICTs permeate various sectors this diffusion would have a significant impact on the whole economy. However, as presented ICT is measured as a sector, which consists of activities in both services and industry, and though the sector has been rapidly growing, has it been able to enable development in Rwanda and has the traditional model for development changed?
ICTs affect all economic sectors, and as a sector ICT has been globally growing. Rwandan policies target growth mainly through developments in the service sector enabled by ICT. The analysis is based on the developments in the ICT sector, and though a major part of the ICT sector consists of online services with low physical barriers, the elements, which enable the access to these activities, are also necessary to analyze. Infrastructure as electricity and cabling for high speed internet are such areas. Other major area, which affects ICT sector growth is the status and investments made in human capital for which education statistics are used. For this reason, the methodology of this research uses data from various sources.

3.1 Data Collection Method

This study is a quantitative analysis of secondary data as a method to review previous development models, designed policies as the Vision 2020 revised report of 2012, sector reports, and Rwanda’s integrated development programs. This study looks into the relationship of Vision 2020 and ICT development between 2000 and 2016.

The study’s uses primarily data from the International Telecommunication Union (ITU), a specialized agency of the United Nations. The data used by ITU is derived from several sources including Eurostat, OECD, IMF, the UNESCO Institute for Statistics, the United Nations Population Division and the World Bank. As the ICT technology is relatively new, some years in specific ICTs are not available and as such the data periods beginning varies from 2000, 2005 and 2010 to 2016.

Other data used to analyze the ICT development is collected by the National Institute of Statistics of Rwanda (NISR) such as the Fourth Population and Housing Census of 2012, Labour Force Survey of August 2017 and Rwanda Demographic and Health Survey 2014-15. Moreover, sector reports, such as the ICT Sector Profiles for 2015 and 2016, provided by NISR in collaboration with particular ministries, in this case the Ministry of Youth and ICT and Ministry of Information Technology and Communications, are used for additional information.

Additionally, World Bank’s World Development Indicators (WDI) are used to cover areas, which were not accessible via national secondary data reports through NISR’s open data sources.
3.2 Limitations of the Data

The data available on Rwanda, and Africa in general, is limited to the beginning of 2000s, as data collection has often started around the year 2000. In the case of ICT development in Africa, this is not essential as ICT diffusion had not begun much earlier. However, for this reason data is collected from various sources, which challenges the reliability of the data comparison.

The limitation of the data becomes inevitable in the case of the definition of the ICT sector. As ICT sector is combined of activities, which cross over the high-levels of ISIC categories such as in trade, manufacturing and services and so also over broad economic sectors. In order to examine the ICT sector’s movements, it would be necessary to access the GDP accounting. Moreover, as the high-level category Information and Communication as well as the alternative aggregation were created just in 2008, there is no long-term data constructed for simple evaluation before this time. Access to data became a challenge and for this reason aggregated macro data is often used, though micro data is needed to make certain assumptions.

The study can also be seen as premature as having ICT enabled development as an area of study. As industrialization, mainly the share of manufacturing in GDP value added, was closely affiliated with development (Perkins et al. 2013, p.11), the possible factors for the future model for development and modernization have not yet been validated as alternative models have not fully progressed. As such, using ICT growth as an indication of ICT sector’s possibilities as the future engine of growth is mainly speculation. Additionally, David (1991, cited in Rousseau, 2006, p.119) noted that ICT productivity growth was not noticed directly after its invention and as the sector continues to grow and foster further innovation as seen in the increased number of patents (OECD, 2017), it can be said that the contents of the sector will continue to adapt. For this reason, also measuring the full effect of ICT remains challenging.
4 Empirical Analysis

The following section presents Rwanda’s structural transformation and economic development, which creates a basis for analyzing Rwanda’s ICT enabled development.

4.1 Structural Transformation and Economic Development in Rwanda

Rwanda has a history unfavorable to development, as conflicts, originating from colonial times and increasing after independence in the 1960s, were common to the country. Though aid had been high already before the genocide, primary products characterized exports and the volatility of commodity prices affected the economy. The genocide against the Tutsi in 1994 marks a turning point, as the change of government resulted in new development policies. The government under president Kagame has actively embedded international recommendations into policies and is engaged to transform with inclusive growth. The ambitious long-term development plan Vision 2020 with the aim of upgrading Rwanda into a middle-income country is still on going, though much is achieved since the deployment in 2000.

Currently, Rwanda has low economic diversity with majority of population employed in agriculture. Examining the employment in economic sectors from 1991 to 2017, figure 4.1 portrays a low structural transformation. Though from 2002 to 2005 a movement from agriculture to services can be detected, industry on the other hand has just slightly increased during the whole period. Over the last decade no major shift can be seen.

![Figure 4.1 Employment in economic sectors (% of total employment) in Rwanda, 1991-2017 (modeled ILO estimate) (WDI, 2018)](chart.png)
Though the latest labor force survey (LFS) report from August 2017 (NISR, 2018) presents a lower share for agriculture (63.1%) and an increase in both employment in industry (11.1%) and services (25.7%) compared to the modeled ILO estimate above, the report acknowledges that almost two-thirds of workers in agriculture are subsistence foodstuff producers, who do not add into productivity. The latest LFS (NISR, 2018) takes into account subsistence foodstuff producers, who could be looking for other work, as unemployed, which increased unemployment to 17.8%. Unemployment was found slightly higher in urban areas (18.5%) than in rural areas (17.5%), but was clearly higher among young people (21.7%) than among adults (14.6%).

The International Labour Organization (ILO, 2018) estimates that Sub-Saharan Africa will experience the highest increase in the total share of global labor force, the supply expected to increase with 198 million people from 2017 to 2030. The ILO estimates the current amount of vulnerable employment at 72.1% and the share of working poor high (extreme working poverty 36.6% receiving under 1.90 US$ a day and moderate working poverty 24.2% receiving under 3.10 US$ a day), which emphasizes the rapid quality job creation, as the pressure of increasing entrants to the labor force may increase these numbers even more. This pressure can be experienced also in Rwanda, where the increasing population size entering the labor force and the high share of subsistence agriculture is challenging development. Though a large share of the population was decimated or fled the country due to the genocide, the population grew at an astounding rate and almost doubled from just under 6 million to over the 11 millions of today (WDI, 2018). In 2017 vulnerable employment accounted for 80% of employment, and though the number has been reducing, the pace has slowed (WDI, 2018).

Rwanda’s GDP per capita has over tripled since 2000, but as the starting point is low, around 200 USD per capita, the country is still stuck in the low-income levels. In contrast, Rwanda shared the same GDP per capita as China in the early 90s before China’s miraculous growth, but the genocide decimated economic activities, and early 90s figures were reached again just in 2005, as shown in figure 4.2.

![GDP per capita (current US$) in Rwanda, 1990-2016 (WDI, 2018)](image-url)
Positively household consumption per adult in Rwanda had increased at a 2.5 % rate per year from 2001 to 2011 and was found to be stronger for the poor than for the non-poor, especially lifting the ones in extreme poverty (World Bank, 2013). Still extreme poverty is widespread, though population receiving under 1.90 US$ a day decreased from 76.5 % in 2000 to 59.5 % in 2013 (39.1 % at national poverty lines) (WDI, 2018). Regionally poverty is higher in rural areas (48.7 %) than in urban (22.1 %) as in 2010 almost half of the rural population lived in poverty according to the headcount ratios at national poverty lines (WDI, 2018). In summary, Rwanda is affected with wide range working poverty in mostly non-productive jobs, which needs to be targeted with quality job creation as accentuated in the ILO report.

Additionally, the value added of economic sectors have been fairly stagnant for almost a decade, though slight changes were experienced as industry grew and agriculture decreased, as seen in figure 4.3. Though agriculture employs three out of four, the sector contributes only less than a third to value added of GDP. Smallholder farms dominate Rwanda’s agriculture and due to the high population density land is scarce, which results in low incomes the smaller the land owned. There is a need for modern farming methods and creation of non-farm jobs and greater urbanization to increase productivity and reduce poverty (Republic of Rwanda, 2012). Exports are heavily dependent on primary products as coffee and tea affected by price fluctuations on the international markets, though minerals have lately increased their share offering a boost to exports (OEC, 2018).

Figure 4.3 also shows that industry’s contribution to GDP is the lowest and for the past decade manufacturing in Rwanda has kept a constant share of around 6 % of total GDP (WDI, 2018). Services then again has absorbed most of the newest labor entrants though its value added has not changed, which could be explained by the difference in productivity within jobs in services.

Figure 4.3 Economic sectors, value added (% of GDP) in Rwanda, 2005-2016 (WDI, 2018)
Rwanda pursues inclusive growth, but development of consumption deciles argues differently. Since 1984 the income or consumption shares in deciles have clearly decreased for all others except almost doubled for the top 10 %, accounting for 43.19 % of all income (PovcalNet, 2018). The genocide and decimation of economic activities takes place in 1994, between the major changes in distribution. Though from 2010 to 2013 a small reduction in the top 10 % shares can be seen, the redistribution to the rest has been very modest as shown in figure 4.4.

![Figure 4.4 Income or Consumption share in deciles (%) in Rwanda, 1984, 2000, 2005, 2010 & 2013 (PovcalNet, 2018)](image)

The figures presented portray Rwanda as a typical poor developing country, which has barely begun its structural transformation. However, the increasing GDP per capita implies that economic sectors are growing and becoming more productive. The following chapter reviews ICTs effect in Rwanda.
4.2 ICT in Rwanda

Rwanda aims to become the leading ICT hub in Africa. The latest ICT Sector Strategic Plan for 2018-2024 (MiTEC, 2017) with an extensive 38-point achievement list reflects Rwanda’s dedication to ICT promotion and the variety of current projects. Achievements or aims vary from 4G LTE coverage to drone industry to Kigali Innovation City (KIC) to establishment of specialized universities or education departments such as the Center of Excellence in Internet of Things (IoT) established at the University of Rwanda in 2016. A full list of achievements can be found in Appendix B.

Rwanda acknowledges that ICT is cross-sectoral, but also its own sector, and as such needs specific attention (MiTEC, 2017). The Rwandan vision for ICT policy is “to modernize the Rwandan economy and society using information and communication technologies (ICTs) as an engine for: accelerated development and economic growth; national prosperity; and global competitiveness” (MiTEC, 2018). Additionally, the matter is often emphasized by the leadership, as in the following quote by Rwandan President Paul Kagame (Smart Africa, 2018):

“If technology is entrenching divides, rather than equalising opportunities, then we are not harnessing it well. Access to technology information must also not distinguish between rich and poor. So long as women and girls are lagging behind then we are not on the right track. We must deliver on technology’s promise to bridge divides, rather than deepen them.

The current chapter pursues to represent the main developments experienced in Rwanda and the impacts on the economy.

4.2.1 ICT Development and Infrastructure

The International Telecommunication Union (ITU) has comprised an ICT Development Index (IDI), which measures the level of ICT development in countries across the world and so allows the comparison across countries and time. The IDI consists of 11 indicators on ICT access, use and skills, see appendix C (ITU, 2016).

The latest IDI for 2016 found that developing countries increased their IDI values more in a year than the developed countries, but that there is still a long way to catch up to the developed country average of 7.40 (ITU, 2016). The ITU (2016) report found out that a strong association between economic and ICT development existed, as all the 27 least connected countries where also least developed and the gap between these countries and high-performing ones has continued to grow. Moreover, Africa clearly lags behind the rest of the world. For this reason, the current section assesses the development experienced in Rwanda in comparison to the region.

According to the index, Rwanda has experienced progress, though still scoring low. Rwanda ranked as 150th out of 175 countries in 2016 with an IDI value of 2.13, showing an increase
from 158th place and a value of 1.79, still clearly preforming lower than the average for developing countries of 4.07, and despite of Rwanda’s efforts, the value was lower than the African average of 2.48 (ITU, 2016). However, Rwanda was one of the only 8 countries, which climbed up the ranking with 5 or more places, enforcing that change is happening in Rwanda. Rwanda’s success has been linear, in 2002 the country had a score of 0.99 and in 2007 this had increased to 1.17, but the country’s ranking was low and downward trending, 136th and 143rd out of 154 countries (ITU, 2009). Though 21 new countries have been added to the recent rankings, the low ranking still shows Rwanda’s slower development comparative to other countries.

The most commonly found ICT device in Rwandan households is the mobile phone with 59.80 %, found clearly more in urban areas with the percentage increasing up to 86.40 %, though rural areas not far behind with 54.2 % (NISR, MOH & ICF International, 2015). Computers on the other hand were not as usual devices, in 2012 about 2 % of all households had a computer, increasing only to 4.5 % in 2016 (NISR, 2012; ITU, 2018b). More ICT devices are found in urban households, Kigali City having the highest percentages (NISR, 2012).

Following the trend of increasing mobile phones in households, the number of active mobile phone subscriptions in Rwanda has been increasing, seen in figure 4.5. In March 2018 the subscriptions reached 9,047,087, corresponding to a 76.61 % penetration rate (RURA, 2018). The ITU (2018a) estimates that the subscription in Africa will be 78 % in 2017, so Rwanda is following closely the general trend.

![Mobile-cellular telephone subscriptions](image)

*Figure 4.5 Mobile-cellular telephone subscriptions per 100 inhabitants in Rwanda and Africa, 2000-2016 (ITU, 2018a)*
Simultaneously fixed-telephone subscriptions both in Rwanda and Africa follow the global declining trend, though the technology was never widely diffused in the first place, even less in Rwanda, as shown in figure 4.6.

Figure 4.6 Fixed-telephone subscriptions per 100 inhabitants in Rwanda and Africa, 2000-2016 (ITU, 2018a)

According to International Telecommunications Union (2018), in 2016 Rwanda had 2.4 million internet users, which is 20% of the population and 1.6 million users more than in 2010. The increase seen in figure 4.7. However, majority of internet users connect through their mobile phones and do not have access to high-speed services.

Figure 4.7 Individuals using the internet in Rwanda and Africa, 2000-2016 (WDI, 2018)
As mentioned, mobile phone penetration is a major factor in increasing access to internet as can be seen when compared the increased mobile-broadband subscriptions to the almost non-existent amount of fixed-broadband subscriptions in figures 4.8 and 4.9. LDCs experienced the highest growth of mobile-broadband subscriptions between 2012 and 2017, though the amount reaches only half of what is in developed countries (ITU, 2018a).

![Active mobile-broadband subscriptions](image)

*Figure 4.8 Active mobile-broadband subscriptions in Rwanda and Africa, 2010-2016 (ITU, 2016; ITU, 2018b; MYICT, 2015)*

Even though Rwanda has laid fiber optic networks across the country the cost to connect is high (ITU, 2016), which reflects the very low amount of subscriptions as shown in figure 4.7.

![Fixed-broadband subscriptions](image)

*Figure 4.9 Fixed-broadband subscriptions per 100 inhabitants in Rwanda and Africa, 2005-2016 (ITU, 2018a)*
As shown the number of individuals using internet has increased, but the number of households with access to internet at home is still low, about 9% in Rwanda, see development and comparisons in figure 4.10. Though the government has been able to assemble the nationwide fiber network, connecting households to the high-speed internet is expensive (ITU, 2016). Consequently, it was found that the most commonly used places to access the internet are cyber cafes and offices or schools (NISR, 2012).

![Households with internet access at home](image)

_Figure 4.10 Household access to internet in Rwanda, 2014-2016 (ITU, 2017; NISR, 2018)_

The 2017 global estimates for the people using the internet, show that of the total population youth, aged 15-24, are the ones most online, with the highest number, 94,3% of the age group found in the developed countries (ITU, 2017). In general, Africa and especially the LDCs lag behind, as only 17,5% of total population use the internet, and only 30,3% of the youth as shown in figure 4.11. However, the growth has been enormous as a decade ago the number of individuals using the internet in Africa was below 3% and almost non-existent in Rwanda as shown in figure 4.7. Still, the low amount of youth online presents a challenge as the mobile-savvy youth are seen as the engine for growth. Moreover, as 39% of the youth using the internet live in China and India, contrasted to the amount of 9 out of 10 young individuals not using the internet found in Africa or Asia and the Pacific (ITU, 2017), the chances of Africa becoming a world leading technology continent in the next years can be doubted. However, in total numbers, due to the rapidly growing population size, the LDCs have the highest number of individuals in the youth group (20,3%) and so have the highest amount of youth internet users (35,1%) (ITU, 2017).
Though electricity is not an indicator in the ITU’s ICT Development Index, but as electricity is a prerequisite for ICT accessibility, it will be discussed for the analysis. National household access to electricity had been fairly slowly increasing, until it almost doubled in four years from around 16% in 2012 to 29% in 2016, representing almost one in three households having access to electricity, as seen in figure 4.12. However, there is a large gap between the urban and rural areas, as only 17.8% of rural households have access to electricity, compared to 80% of urban households. Additionally, in 2000, rural households had no access to electricity, while 39% of urban households were already connected.
However, the before mentioned figures are based on surveys focusing on household use of electricity for lighting, which do not consider off-grid electricity sources, such as solar power. Also, electricity access is tackled in various phases, the first level sufficient for household lighting, radio and phone charging, as the government acknowledges that full electricity access is not possible to provide for the whole country simultaneously, and still in 2016 targeted 100 % by 2020 (MININFRA, 2016).

The latest government data suggests that Rwanda’s national electrification rate is actually 42 %, of which 31 % on-grid and 11 % off-grid, and the 100 % electricity access target has been pushed to 2024, while the plan has evolved to include a bigger share of off-grid electricity, representing almost half of total (52 % on-grid, 48 % off-grid) (REG, 2018). The off-grid solutions are especially installed in areas far from the on-grid network, as the level of electricity consumption and incomes are not compatible with the costs of expanding the on-grid to every household (MINIFRA, 2016). This decision can be seen from the current figures for urbanization and on-grid electrification. In 2013-2014 Kigali City had a 76 % urban population, while urbanization in the rest of the provinces ranged between 7 % and 12 %. Similarly, Kigali City had the highest proportion of electricity, 71 %, in other provinces the proportion of households using electricity ranged between 10 % and 19,5 % (NISR, MOH & ICF International, 2015). Additionally, it is seen that as electricity contributes to economic development, especially productive users are to be prioritized and as such Kigali City households will be receiving a 100 % connectivity rate in the near future (REG, 2018). However, Kigali City province represents only 10,7 % of the total population, though it is the most densely populated area (in addition to Rubavu district on the border of Congo) (NISR, 2012).

Additionally, a recent impact evaluation of Rwanda’s Electricity Access Roll-Out Program (EARP) (Lenz, Munyehirwe, Peters, & Sievert, 2017) found that the quantity of consumed electricity and the uptake of appliances remained low after access to electricity and that electricity mostly facilitated people’s lives such as in increased lighting usage, however mainly for non-productive purposes. In conclusion, the study found only weak evidence for impacts on classical poverty indicators such as income, health, and education, and also questioned the benefits of on-grid electricity installation as 30 % of population who had access to electricity did not connect, mainly due to cost reasons.

Even though EDPRS2 set connecting rural communities to economic opportunities through improved infrastructure as one of the key development investment priorities, the decision to prioritize urban areas where incomes are already higher, could increase the gap between urban and rural, and not contribute to poverty reduction as strongly as it is the non-productive subsistence farmers who need to be targeted. However, as electricity brought only weak linkages to poverty reduction, other actions need to be taken. Also, encouraging the economic activities in urban areas will create jobs, which can be filled by the rural population moving to cities.

As part of LDCs, Rwanda’s efforts to rapidly diffuse access to ICTs countrywide seem profound as, even in the continent, they are behind. However, the benefits of these actions might not yet be visible. Moreover, following the global trend, Rwanda also experienced greater improvement in ICT use than access, though the highest growth in Africa came from
increase in mobile phone subscriptions, not from mobile-broadband subscriptions as for the rest of the world, which can be explained by the low economic development preventing ICT development (ITU, 2016). However, positively Rwanda was one of the few countries, which had strong improvement in mobile-broadband penetration (ITU, 2016). Still Rwanda can only receive relatively high scores from mobile-cellular subscriptions and international Internet bandwidth per Internet use, not forgetting a very weak performance on fixed-telephone subscriptions and on the proportion of households with a computer or with Internet.

Figure 4.13 ICT development in Rwanda, 2000-2016 (ITU, 2018a; WDI, 2018)

The gaps between Rwanda and Africa to the developed countries are substantial as seen in table 4.1 below.

Table 4.1 ICT figures in Rwanda, Africa and Developed countries (ITU, 2018a; ITU, 2018b)

<table>
<thead>
<tr>
<th></th>
<th>2016</th>
<th>Africa</th>
<th>Developed Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed-telephone subscriptions</td>
<td>0,1</td>
<td>1,0</td>
<td>38,1</td>
</tr>
<tr>
<td>Mobile-cellular telephone subscriptions</td>
<td>74,9</td>
<td>74,6</td>
<td>127,3</td>
</tr>
<tr>
<td>Active mobile broadband subscriptions</td>
<td>35,0</td>
<td>22,9</td>
<td>94,4</td>
</tr>
<tr>
<td>Fixed-broadband subscriptions</td>
<td>0,2</td>
<td>0,4</td>
<td>30,3</td>
</tr>
<tr>
<td>Households with internet access at home</td>
<td>9,3</td>
<td>16,3</td>
<td>82,9</td>
</tr>
<tr>
<td>Individuals using the Internet</td>
<td>20,0</td>
<td>19,9</td>
<td>79,6</td>
</tr>
<tr>
<td>Households with computer</td>
<td>4,5</td>
<td>-</td>
<td>81,5</td>
</tr>
</tbody>
</table>
4.2.2 ICT in Education and Skills Development

Increasing human capital is the main resource for innovations and ICT is set to be mainstreamed throughout all levels of education with plans such as the Smart Classroom Programme where access to computers, basic education software and internet are provided (MiTEC, 2017). In general terms, universal primary education has been achieved, the quality of education and increase in the mean years of education are still a challenge. Rwanda has a high primary school enrolment rate compared to Sub-Saharan African average, but scores slightly lower in secondary enrollment though catching up in tertiary, shown in table 4.2. However, secondary and tertiary figures are low compared to the developed world, and it is clear that attaining higher educational degree is necessary. From 2000 to 2012, the adult literacy rate moved up only from 64.9 % to 68.3 %, when correspondingly, youth literacy rate increased from 77.6 % to 82.3 %, portraying a higher share of literate population that will enter the labour force in the future (WDI, 2018).

Table 4.2 Education statistics in Rwanda and Sub-Saharan Africa, 2000 & 2016 (WDI, 2018)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary enrollment ratio (%) gross</td>
<td>108.6</td>
<td>137.0</td>
<td>81.8</td>
<td>97.3</td>
</tr>
<tr>
<td>Secondary enrollment ratio (%) gross</td>
<td>10.7</td>
<td>36.7</td>
<td>25.8</td>
<td>42.6</td>
</tr>
<tr>
<td>Tertiary enrolment ratio (%) gross</td>
<td>1.3</td>
<td>8</td>
<td>4.5</td>
<td>8.8</td>
</tr>
<tr>
<td>Mean years of schooling</td>
<td>2.3 (2015)</td>
<td>3.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary completion rate (% of relevant age group)</td>
<td>23.2</td>
<td>67.3</td>
<td>54.3</td>
<td>69.5</td>
</tr>
<tr>
<td>Literacy rate, adult total (% of people ages 15 and above)</td>
<td>64.9</td>
<td>68.3 (2012)</td>
<td>56.3</td>
<td>64.4</td>
</tr>
<tr>
<td>Literacy rate, youth total (% of people ages 15-24)</td>
<td>77.6</td>
<td>82.3 (2012)</td>
<td>66.4</td>
<td>75.3</td>
</tr>
</tbody>
</table>

Kigali City represents the most educated province with a quarter having attained secondary education and about 7 % tertiary, while in the rest of the provinces 10-13 % of population have secondary and about 1 % tertiary education (NISR, MOH & ICF International, 2015).

Moreover, in skills development Rwanda was 161st in the IDI ranking without any development from 2015 (ITU, 2016), but it must be noted that skills development takes time and might not be feasible to judge within a year’s period. Though skills are the key to maximize the impact of ICTs, as correct skills are needed to exploit new technology and reap the benefits (ITU, 2016). However, as the skills component measures mean years of schooling, secondary and tertiary gross enrollment ratios, and as such is not a direct measure of ICT. Acknowledging this, ITU has given less weight on skills in the total composition. Additionally, the report notes that there is more disparity between the overall IDI value and skills, which could depict that skills might give an implication of a country’s potential but does not necessary set it on a certain path, as ICT can be used efficiently though not having high skills, such as learning on the job.
4.2.3 ICT in the Labor Market

The labour force survey of August 2017 (NISR, 2018) accounted the population size of 16 years and over as 6,812,977. However, only 3,600,919 were calculated as labour force, bringing the labour force participation rate to 52.9% and employment-population ratio to 43.4%. As total population was 11,697,313, there is a massive dependent population, mainly consisting of young people. The mean age of population in Rwanda in 2012 was 22.7 years, but as one in two persons were under 19 years of age, there is a bigger workforce upcoming (NISR, MINECOFIN, 2012).

In 2017, agriculture dominated as the economic activity with the highest number of employed persons, followed by trade (16.6%), construction (10.3%) and activities of households as employers of domestic personnel (6.8%) (NISR, 2018). Kigali City employs the highest amount in services (74%), while in the rest of the provinces services is second to agriculture (NISR, 2018). In 2016, service sector absorbed labor from agriculture but also most of the new entrants to labor force, and though the growth of productivity has not been high, a significant increase could be seen in financial services, transportation, communications and ICT (World Bank, 2017). Additionally, labor productivity in the financial sector and ICT was found very high, although these sectors combined employed less than 16,000 workers (World Bank, 2017). According to the Vision 2020 (Republic of Rwanda, 2012) Rwanda’s government supports the use of ICT as a tool for self-employment, innovation and job creation, especially targeting the youth. ICT jobs as percentage of formal jobs were estimated at 2% in 2017 (MiTEC, 2017). However, World Bank (2017) suspects the ability of the two aforementioned economic sectors to absorb labor from the mainly low skilled labor force supply as the sectors require mostly high skill labor for growth and so sees manufacturing as the most effective sector.

A look into economic branches reveal that a majority, 68%, of all employed in Information and communication reside in Kigali City and of the total amount a third were females (NISR, 2018). This branch of economic activity was one of the only two branches, other being Financial and insurance activities, which in total did not have any employed population without education. In addition, the amount of employed grew the higher the education level, which could signify that the branch requires but also attracts educated population. Though, Information and communication employed only 3% of all university educated. Distinctively, the highest amount of population with the highest education level (university) were absorbed into Education, while the following three branches employed fairly equal amount of the population within the same education level: Public administration and defense, Human health and social work activities and Wholesale, retail trade, repair of motor vehicles, motorcycles (NISR, 2018). Moreover, 72% of Information and communication is estimated as informal employment (NISR, 2018).

Table 4.3 Employed persons by Information and Communication in 2016-2017 (NISR, 2018)

<table>
<thead>
<tr>
<th>Indicator</th>
<th>%</th>
<th>Number</th>
</tr>
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<tbody>
<tr>
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</table>
Rwandan government has stated that around 200 000 jobs need to be created annually and the latest LFS in 2017 (NISR, 2018) estimates that about 155,994 off farm jobs were created in addition to 95,502 farm jobs adding up to a total of 251,496 jobs, which saw a 9 % increase from 2016. In absolute numbers the sector, which contributed most to the creation of jobs, almost half of the total, was whole sale and retail trade; repair of motor vehicles and motor cycles. The other sectors with the highest job creation, but also with negative job creation are listed below in table 4.3, and as shown Information and communication is not mentioned.

Table 4.4 Job creation within economic branches, 2016-2017 (NISR, 2018)

<table>
<thead>
<tr>
<th>Sector</th>
<th>Jobs created in 2017</th>
<th>Change in job creation from August 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole sale and retail trade; repair of motor vehicles and motor cycles</td>
<td>104,478</td>
<td>+ 25 %</td>
</tr>
<tr>
<td>Agriculture</td>
<td>95,502</td>
<td>+ 9 %</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>20,943</td>
<td>+</td>
</tr>
<tr>
<td>Activities of households as employers</td>
<td>20,376</td>
<td>+</td>
</tr>
<tr>
<td>Mining and quarrying</td>
<td>17,472</td>
<td>+</td>
</tr>
<tr>
<td>Accommodation and food service activities</td>
<td>-73,209</td>
<td>-</td>
</tr>
<tr>
<td>Other services</td>
<td>-8,713</td>
<td>-</td>
</tr>
<tr>
<td>Administrative and support activities</td>
<td>-5,041</td>
<td>-</td>
</tr>
<tr>
<td>Construction</td>
<td>-4,448</td>
<td>-</td>
</tr>
<tr>
<td>Water supply, gas and remediation services</td>
<td>-1,892</td>
<td>-</td>
</tr>
</tbody>
</table>

As per the implementation of the Vision 2020 in 2000, Rwanda has succeeded to create 1,2 million non-farm jobs up to 2012 (Republic of Rwanda, 2012). However, much more quality jobs will be needed, considering that informal employment rate was 90,8 % in 2017 (NISR, 2018). Additionally, the inequality in incomes also mentioned before can be seen in the average incomes from paid employment of employees at main job with 58,677 RFW (68
USD) a month, while the median was as low as 20,800 RWF (24 USD) (NISR, 2018). Figure 4.14 shows that highest incomes are received in services. Also, monthly average incomes increased from August 2016, though due to only a slight increase in services, while the development in agriculture and industry was negative (NISR, 2018).

![Figure 4.14 Income per month by broad economic sectors in Rwanda, in RWF in 2016-2017 (NISR, 2018)](image)

Rwanda is often commended for work towards gender equality. In 2016 Global Gender Gap Report ranked Rwanda 5th for being one of only five countries to have closed at least 80 % of its gender gap, in addition to globally having the highest share of women in the parliament (WEF, 2017). Though the country’s history shows that women’s participation as active labor force has been necessary, as a majority of genocide survivors were women, the low income levels of agriculture could be partly explained with gender inequality. Though the income difference between genders is not revealed via the current household surveys, but as rural work is female dominated and clear inequality persists between men and women in the access to economic resources within rural poverty (Republic of Rwanda, 2013), it is to be noted. As agriculture is mostly informal, it can be thought that the improvements are measured through formal and higher productive jobs and so moving labor force to non-farm jobs could be an equalizing factor.

4.2.4 ICTs’ Role in Economic Growth

ICT sector has continuously been among the largest contributors to GDP growth with 3 % share in 2015 and 2016 (MYICT, 2015; MiTEC, 2016). In 2015 ICT accounted for 5,4 % in OECD countries, so Rwanda is rapidly catching up (OECD, 2017). Also ICT sector average growth in 2015 was 16 %, which is rapidly faster than the rest of the economy with 6,9 % (MYICT, 2015).
Rwanda’s government’s strategic infrastructure investments on ensuring connectivity have led to increased investments (Deloitte, 2014). Foreign direct investments (FDI) are found to create industries and jobs, support technology inflow, skills development and also increasing access to global trade (Perkins et al. 2013, p.365-367). Previously, FDI directed to globally competitive manufacturing was seen increasing growth and development, with other main receivers being exports in primary products as tropical agriculture or natural resources, where a country’s comparative advantage is found (Perkins et al. 2013, p.364, 685). Openness to FDI results in an increase in production and also in exports.

The investments are largely private as found from the Rwanda Official Development Assistance (ODA) Report (MINECOFIN, 2017). In 2015/2016 ICT received only a 0,3 % disbursement, though ICT was set as one of EDPRS2 main areas of investment with a 5,2 % share allocated for the sector. ICT was one of the smallest shares of the total development finance from donors, while agriculture dominated the public investments. However, the report continues to inform that ICT was one of the main receivers of foreign private investments (FPI) in 2014 with FDI amounts exceeding ODA many times and collecting together the amount originally intended by EDPRS2. Rwanda aims towards lower aid dependency and has succeeded to decrease the amount to around 11 % of GDP in 2016 with increasing foreign private investments supporting the development of a selfsustaining inclusive poverty-reducing growth model (Republic of Rwanda, 2012; MINECOFIN, 2017).

Rwanda experiences a trade deficit as in 2016 exports of goods and services accounted only 15 % of GDP, while imports where more than double, 33,2 % of GDP (WDI, 2018). Similarly, the share of ICT goods of total imports outweighs the share of exports by tenfold, and neither has experienced a change in a decade. However, ICT imports were almost double
the average in Sub-Saharan Africa, which could represent the country’s efforts in rapidly diffuse the technology. Additionally, though the low goods exports partly represent the state of manufacturing in Rwanda, it is necessary to note that manufacturing is not in the country’s future plans, as a “zero kg export” through ICT services is promoted (MiTEC, 2017). Following Rwanda’s visions to invest in skills development and services, ICT service exports, which include computer and communications services (telecommunications and postal and courier services) and information services (computer data and news-related service transactions) had increased slightly from 2010 to 2016 (respectively 3,4 % and 5,2 % of service exports, balance of payments), though in this case being lower than Sub-Saharan average (WDI, 2018).

Table 4.5 Information economy indicators (as % of) (UNCTADstat, 2018)

<table>
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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Share of ICT goods, % of total exports</td>
<td>1,20</td>
<td>0,60</td>
<td>0,81</td>
<td>1,00</td>
</tr>
<tr>
<td>Share of ICT goods, % of total imports</td>
<td>9,28</td>
<td>7,10</td>
<td>9,82</td>
<td>9,82</td>
</tr>
</tbody>
</table>

Furthermore, Rwanda’s gross capital formation, including areas such as construction of roads or schools, hospitals and industrial buildings, equipment or machinery purchases, has rapidly increased from 13 % in 2000 to 26 % in 2016, surpassing the LDC average, but also the high-income countries (WDI, 2018). This portrays the effort to provide the necessary environment for a functioning modern economy.

4.3 Discussion

This study set out to assess whether prioritizing ICT has enabled development in Rwanda in 2000-2016. Whether the ICT sector and the effects of ICT diffusion are able to modernize a developing country, the prospects of the traditional path to modernization is first examined. Industrialization or modernization follows a structural transformation of labor moving from agriculture to industry with a creation of a manufacturing sector. In fact, a productive and market-oriented agriculture is one of Vision 2020’s main pillars. However, agricultural modernization has not been successful due to the small size of farms and that food is not produced commercially, but consumed by the household (ACET, 2017). Though the government diffused fertilizers and training, but also digital solutions as esoko (e-marketplace) have become common and even dispersing students with new knowledge onto the field, it could be thought that as the investments are not being fundamentally transformative, as Rosenstein-Rodan’s big push theory suggests, the effects are still minor.

With a growing population and majority already employed in agriculture, Verpoorten (2014) notes that subsistence farming cannot be seen as an option for the future generations as the estimated density will be too high to distribute land to the same share of population as
currently. Moreover, as the main products are coffee and tea, and though productivity and exports could increase, it will not be enough to develop the Rwandan economy (Republic of Rwanda, 2012). UNCTAD (2014) also found that African LDCs, dominant exporters of food and agricultural goods, but also LDCs specialized in the export of minerals, had shown low or even negative changes in agricultural productivity and transformation of employment. This could imply that the increase in the export of these products, as was the development with minerals in Rwanda, will not lead to development. Also, as a landlocked country, Rwanda faces natural barriers to trade as distances are long, and no railway systems have been built to connect the country to the countries in the region or to major ports, which increases the price of exports and imports and so not making the industry and its transported goods favorable (Republic of Rwanda, 2012). All the above recommend a movement of labor away from agriculture, though the target set in Vision 2020 becomes even more necessary. The growing population needs increased food production due to increased consumption and as imports are expensive, food security needs to be obtained.

On the other hand, Lewis (1954) noted, the movement of labor away from agriculture was in search of higher wages. In Rwanda’s case, there has not been a large sector to move into as manufacturing has been low. Also, in general wages are low whereas subsistence agriculture in the least provides nutrition. Though it can’t be argued that there is no movement as the latest LFS showed an increase in manufacturing jobs created. Still, job creation in wholesale and trade was significantly higher.

As noted, manufacturing has a low and stagnated contribution to GDP value added, the sector has not operated as the engine of growth as in the past. Though authors such as Ggombe and Newfarmer (2017) claim that structural change in Rwanda is in fact happening but in an inverted order of services growing first and then labor moving to manufacturing. However as stated in Vision 2020, Rwanda does not intend to focus on manufacturing, but as in ICT, it will continue to import goods and concentrate on the specialized human skills needed to run and maintain the technological systems within different fields along all economic sectors. Rwanda’s economic development since 2000 shows that the service sector has a high contribution to GDP and that the sector absorbs the most new entrants.

Additionally, as noted before the line between industry and services has blurred (UN DESA, 2008; Ghani & O’Connell, 2014), which could imply that in order to modernize, manufacturing might not be a needed step. Moreover, current services complement manufacturing, as large manufacturing firms tend to have large support services (AfDB, OECD & UNDP, 2017). This is partly enabled by the wide permeation of ICTs, which have impacted the way we operate, but also has made the direct impact of ICT challenging to measure. In conclusion, the traditional way of measuring and categorizing between the main economic sectors of agriculture, industry and services will not be viable.

The possibility of the traditional path to modernization being available for the still developing countries is challenged. Rwanda’s development model could be seen as a combination of Stiglitz multifaceted growth strategy with an ideology taken from Rosenstein-Rodan’s big push. Though big push was focused on jump-starting industrialization, the idea of doing everything at once as Millenium Development Goals fixing all aspects of the economy (The Economist, 2011) or Rwanda making large investments in ICT and building all the necessary
infrastructure for a conducive market environment. The ICT sector does not require similar heavy capital as industrialization, though the necessary ones as electricity and internet access still promotes productivity in agriculture and industry. Additionally, not installing fixed-telephones but having a major increase in mobile phones is seen as leapfrogging technology, and so prioritizing ICT and services benefits other sectors, reaching developments which other sectors’ traditional operations have not pushed for in the past.

However, as the figures show, electricity access is still not universal, and only mobile-broadband subscriptions were above the African average. Rwanda’s ICT development took off after 2012, which could mean that the low diffusion would not be related to the wait for price reductions as suggested earlier, but possibly because of the low purchasing power of local firms to use electricity and ICT products, or in general upgrade their operations. However, it could then be thought that as the country is now effectively imposing the adoption, leapfrogging is possible as no capital needs to be updated. Though due to the low purchasing power and mostly rural economy, there might still not be demand for new technology and so innovations will be low. Additionally, having higher diffusion of ICTs might still not lead to taking advantage of the eased connectivity and possibilities provided, as the impact evaluation EARP found out. The study researched only farmers and as this group could be assumed to be one of the least educated group, the ICTs were not used for productivity gains, but for leisure and entertainment, a study with another target group could be more revealing. Rwanda as the rest of Africa bursts with small firms and own account workers, often within informal service markets, it could be interesting how these groups make use of ICT for productivity gains.

Still Rwanda has a substantial amount of modern ICT services compared to that the it is one of the poorest and least developed countries. Infrastructure for startup hubs and joint working spaces are established. These are mainly supported by the active and forward-looking government. Rwanda’s successful stability, run by its long-term president borders democracy, is seen as a model for others with Rwanda’s institutional development ranked higher than the Sub-Saharan average in 2015 (WEF, 2014).

ICTs affect the economy such as bringing efficiency with eliminating time-consuming activities, such as trips to banks and offices due to registrations being fully operational via internet. However, the gap between rural and urban poverty could persist. Challenges are imposed by the low rural electrification, which will not allow the charging of electrical equipment, in addition to the traditional ways of operating such as carrying produce on the heads, which will not be affected by electricity or internet access as goods need to be transported to markets (Financial Times, 2015). However, Rwanda is one of the African countries with the highest urban growth rates at 3.7% annually (2010-2015) (PRB, 2015), still resulting in only 29.8% of population in 2016 (WDI, 2018). Whereas for manufacturing Africa’s sparsely populated land with the exception of a few highly populated cities, could be challenging as concentration is low, the connectivity provided by ICTs still allow work from a distance. Though ICT could be an equalizing factor in space as rural and urban divide, an internet use imbalance between the genders was globally found to exist (ITU, 2018a). Education will take a major role in providing skills equally among genders. Rousseau (2006) concluded that due to the unfinished implementation of ICT among companies and
households together with the reduction in prices and the increasing ICT literacy of the youth convincingly predicts that the most productive phase is yet to come.

Though Rwanda wouldn’t follow in building a manufacturing sector, the country can still look for examples from Asia. Rwanda has a beneficial demographic dividend, which is associated with increased supply of labor, more savings and investments, technological progress, and growth, similar to the East Asian Miracle countries, though the gains are not automatic (Ghani & O’Connell, 2014). The large number of better-educated, more online youth support the vision of becoming a knowledge-based service-oriented economy. While FDI in China was successfully directed towards manufacturing, in Rwanda the highest receiver is ICT. Though population growth and density are high, Rwanda’s small population size compared to the region might be advantageous, as globally the ICT sector has not yet proven to absorb a great amount of labor force, but being a forerunner and prioritizing the sector, Rwanda could become the technology hub of Sub-Saharan Africa. Globally the gap in ICT diffusion and skills is vast, and so Rwanda has to compete regionally with regionally relevant solutions.

However, quality job creation is one of the main challenges. Though 200,000 jobs were to be created each year to cover the number of entrants, there is a large number of individuals in unproductive jobs or unemployed, and as such the number of jobs created needs to be increased. The youthful population must be employed successfully in a similar way as was mobilized in Asia, as this is clearly Africa’s asset. However, as 9 out of 10 African youths are not using the internet (ITU, 2017), the challenge is to become globally competitive. This might also lead to only a minority of privileged, educated and rich youth taking part in the digital revolution. As such, one of the main challenges for ICT to enable modernization in Rwanda is its ability to employ masses. Employment is on the shoulders of the private economy, but with FDI directed towards ICT being higher than ODA supports the building of a private sector-led economy. The government has been very proactive in supporting entrepreneurs and foreign business investments and eliminated barriers to entry. Rwanda’s higher rankings on World Bank’s Doing Business portray a stable and favorable environment for new investment opportunities.

Specializing in specific ICT skills could be seen as comparative advantage. It could be argued that while China stopped being a low labor cost country years ago, countries continue to exploit China due to the type of skills on supply, in example in high tech product manufacturing, and especially due to the high quantity of skills available in one place. Also, China currently has a 20% share of all research and development expenditure, and as such replaced its former title of the world’s assembly hub to a technology hub (Forbes, 2017). However, the current skill level in Rwanda might be insufficient. According to the LFS (NISR, 2018), 23% of the population who received trade and technical training, where unemployed, which shows that there is a mismatch between the training and job opportunities or requirements. Similarly, current professional training is lagging, including in ICT, which challenges the expectations of having suitable skilled labor force (Republic of Rwanda, 2012).

As the low quality of schooling in Rwanda has shown, the challenge might be that the workforce will not be suitable for the jobs and the companies planning to exploit the low labor force costs need to first train their workers. Learning the skills on the job might be the
answer, as though the workforce might learn skills for a specific job, the developing technology requires constant training. As the majority of the labor force is still learning, the tech jobs are already on offer and the ones possessing the right skills are highly sought after and so possibly increasing the wages. Eventually, creating a middle class is a challenge Rwanda has to address. Inequality in income distribution marks its turning point between 1984 and 2000, when the top 10 % shares increased extensively. No major change has happened since and as average incomes are low and so the purchasing power, it will have an adverse effect on the domestic service sector.

Additionally, even though the education sector would improve, it could be down to the next generation to enter the labor force with the needed skills and so Rwanda will not fully join the digitalization movement at the present. As the ICT sector is heavily dependent on the right skills, it will need high investments in education but also possibilities created after graduation which will need government intervention such as cooperating with international companies to set up operations in the country, not only in the capital Kigali.

4.3.1 Summary

Though Rwanda has barely begun its agricultural revolution neither industrialized, modernization is happening. In general, the findings represent Rwanda’s visions of educating the youth and building the infrastructure to suit the needs of a growing information economy. A modern service sector with support from ICT infrastructure has begun to shape the urban areas, mainly the capital Kigali, while the rest of the country is following further behind.

It is clear that ICT has brought along benefits, in example mobile banking or the farmer having access to instant market prices, disease control information or the weather conditions (Deloitte, 2014), but also just made life easier even if just with connectivity or entertainment (Lenz, Munyehirwe, Peters, & Sievert, 2017). However, as the diffusion is still not experienced universally, changes in large-scale are not experienced, but also because of the gestation period of ICT productivity in relation to improved investments in human capital and research and development (Crafts, 2006, p.25). Brynjolfsson and Hitt (2000, cited in Crafts, 2006, p.36) note that ICT brings higher long-term returns, but changing the organizational structure and learning the specific capabilities of ICT suitable for a certain business takes longer time. Though technological advances have at first kept wages stagnant and inequality has increased, eventually the majority has benefited from the new technology as history has shown with the industrial revolutions and GPTs as electrification. As such the recent high growth rates and inequality in Rwanda are less the outcome of ICT, rather than Rwanda starting from a very low level with growth derived from infrastructural and institutional development and having concentrated income distribution. Moreover, these developments began before the introduction of ICT. Additionally, other GPTs as electricity with similar productivity improvements have also not been universally implemented. As such productivity gains from ICT can be expected as well as leapfrogging as Rwanda does not need to install all earlier technological innovations, such as fixed telephone lines.

Rwanda might be able to develop with ICT, but as shown competing globally will be challenging as skills, infrastructure and job creation are still insufficient. As such Rwanda
should focus on creating solutions for the regional market, as contextual knowledge creates innovations, such as mobile banking. Though in order to provide a platform for young entrepreneurs to take off to the digital markets, the price of especially the fixed-broadband needs to be reduced as currently the costs are too high for starting businesses, and especially for residential use. As often mentioned the challenge in Africa will be job creation as even more are entering the labor force. The young information age entrepreneurs need to be encouraged and supported to grow their companies and hire others. However, the challenges for tech-entrepreneurs seen by IFC (2018a) of insufficient infrastructure, unreliable electricity and connectivity and limited funding, seem to be addressed in Rwanda.

As the education statistics show, in order for Rwanda to internationally or even regionally compete in ICT services, the education levels need to be increased and ensured that quality education reaches the students. Responding to the skills mismatch, online workshops and trainings are available for individuals and so relying on public education to prepare the labor force is less determining.

ICTs including internet access have become generally available in Africa only less than a decade ago. Most of the research bases on the arrival of ICT and discusses the new economy, but the utilization has rapidly increased after 2012 as Rwanda figures show, and thus the situation might be different. However, as was already found by UNCTAD (2007), that though developed countries reach productivity gains from the actual use of ICT, while in developing countries this is created by the growing ICT sector implying the increased sales and uptake of ICT devices. However, though the growing ICT sector can be confirmed by the statistics of Rwanda, this does not necessarily abide that the use is not growing. As this study was not able to find data for the growing use, the current enthusiasm and government actions show a positive future.

Moreover, as there is a variety of ICTs and all have a different impact, the effect is challenging to measure. It was noted earlier by UNCTAD (2007) and OECD (2017), that the developed countries increasingly produce the ICT software, rather than manufacture the physical devices. As Rwanda has stated its interest is not to manufacture, but to maintain, it is already stepping towards the path of developed countries. It can be noted that the ICT sector has room to grow. Though in order to have a fully functioning workforce for the digital economy, it will might need a generational change for the policy changes to make an impact. In this time, Rwanda will miss the current hype caused by ICT and the knowledge economy. It can also be concluded that more time is needed to be able to evaluate the progress in Rwanda.
5 Conclusion

It is clear that Africa lags behind and though Rwanda has made major strides, the country still has a long way to catch up. Also, it is already clear that Rwanda will not reach all the targets set to achieve by 2020, such as graduating to middle-income country or reaching 100% electricity access across country. New goals have been set to reach the income status by 2035 and further to become a high-income country by 2050, though universal electricity will remain targeted by 2024.

Though no large-scale structural change has yet been seen, the country has experienced development. Whether Rwanda is actually leapfrogging or doing everything at once is still yet to be seen, as government visions realize. Though a comparative advantage might have not been found yet, FDI is increasing with ICT as the main receiver. Aid has been directed efficiently for pro-poor activities, major share going to agriculture. The declining share of aid in GDP could predict stronger domestic markets. The ambitious and committed visions of the country as technology hub might be a factor for the increase, but so is the stable, low corrupt and entrepreneurship supporting business environment created by the government.

It could be concluded that government-led actions are able to transform a country’s economy. Rwanda being active, experimental and up to date of global movements has made some major updates as providing access to internet, though the targets are to be attained later than expected. The Vision 2020 launched in 2000 was ahead of time, and the first effects can just now be seen as the preconditions of a knowledge-based economy require a generational change with skills development but also catch up in infrastructure taking time and large investments.

As various research shows, measuring the effects of ICT is challenging, but also as many studies concentrate on the late 90s arrival of ICT, this thesis brought up the need for new exploration of the topic in the light of current events of ICT becoming even more connected and necessary for everyday life and work. It is not only a tool for productivity but an irreplaceable mode of work.

5.1 Future Research

This study is a comprehensive review of ICT in Rwanda, which brought up various future research areas, such as the definition of ICT and measuring the impact of ICT in an economy. This study would have benefited from interviewing stakeholders in the Rwandan ICT sector and conducting a field research on electricity and ICT access and the effect on incomes could be of inspiration for a more in-depth future study.
The study also challenges the categorization of main economic sectors of agriculture, industry and services, as services increasingly due to ICT are embedded into the daily functions of each economic activity, though still ICT sector is treated as a separate sector. However, as defined ICT sector crosses over these broad economic branches. An analysis of the job creation and income levels of technology companies, start-ups and ICT supported service branches since 2000 could expand the discussion on the expectations of the employment opportunities of the ICT sector. Additionally, ICT's role in gender equality and an empirical research analyzing the digital literacy skills of the labor force and the ability of the education sector to enhance theses skills, could be suggested as research subjects.
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rwanda-beats-almost-every-other-country-in-gender-equality/ [Accessed 12 December 2017]
Appendix A

ICT sector (UN DESA, 2008)

<table>
<thead>
<tr>
<th>ICT manufacturing industries</th>
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</thead>
<tbody>
<tr>
<td>2610 Manufacture of electronic components and boards</td>
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<tr>
<td>2620 Manufacture of computers and peripheral equipment</td>
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<tr>
<td>2630 Manufacture of communication equipment</td>
</tr>
<tr>
<td>2640 Manufacture of consumer electronics</td>
</tr>
<tr>
<td>2680 Manufacture of magnetic and optical media</td>
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</tbody>
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<tr>
<th>ICT trade industries</th>
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</thead>
<tbody>
<tr>
<td>4651 Wholesale of computers, computer peripheral equipment and software</td>
</tr>
<tr>
<td>4652 Wholesale of electronic and telecommunications equipment and parts</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>ICT services industries</th>
</tr>
</thead>
<tbody>
<tr>
<td>5820 Software publishing</td>
</tr>
<tr>
<td>61  Telecommunications</td>
</tr>
<tr>
<td>6110 Wired telecommunications activities</td>
</tr>
<tr>
<td>6120 Wireless telecommunications activities</td>
</tr>
<tr>
<td>6130 Satellite telecommunications activities</td>
</tr>
<tr>
<td>6190 Other telecommunications activities</td>
</tr>
<tr>
<td>62  Computer programming, consultancy and related activities</td>
</tr>
<tr>
<td>6201 Computer programming activities</td>
</tr>
<tr>
<td>6202 Computer consultancy and computer facilities management activities</td>
</tr>
<tr>
<td>6209 Other information technology and computer service activities</td>
</tr>
<tr>
<td>631 Data processing, hosting and related activities; web portals</td>
</tr>
<tr>
<td>6311 Data processing, hosting and related activities</td>
</tr>
<tr>
<td>6312 Web portals</td>
</tr>
<tr>
<td>951 Repair of computers and communication equipment</td>
</tr>
<tr>
<td>9511 Repair of computers and peripheral equipment</td>
</tr>
<tr>
<td>9512 Repair of communication equipment</td>
</tr>
</tbody>
</table>
Appendix B

ICT sector status, achievements and challenges (MiTEC, 2017)

Ministry of Information Technology and Communications

7. ANNEXES

ANNEX1: ICT SECTOR STATUS, ACHIEVEMENTS AND CHALLENGES

<table>
<thead>
<tr>
<th>#</th>
<th>Achievement</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Increased phone penetration</td>
<td>In 2010, the phone penetration was at 33%. It has greatly increased to 79.2% in 2016.</td>
</tr>
<tr>
<td>2</td>
<td>Internet Penetration</td>
<td>In 2011, the internet penetration was at 7%. It has increased to 39.76% by 2017.</td>
</tr>
<tr>
<td>3</td>
<td>4G LTE Coverage</td>
<td>Since Rwanda signed an agreement with Korea Telecom in 2013, 4G LTE was introduced and now has been rolled out by 64.3% population coverage across the country.</td>
</tr>
<tr>
<td>4</td>
<td>Mobile Financial services</td>
<td>The Mobile Financial Service subscribers in 2011 were 639,000. This increased to 9,700,000 by the year 2016.</td>
</tr>
<tr>
<td>5</td>
<td>Positivo Plant</td>
<td>In 2014, the GoR signed an agreement with the Latin American multinational POSITIVO and established a local computer assembly plant. Since July 2015, POSITIVO BGH plant has assembled 95,580 laptops to date including 24,180 XO (OLPC) and 71,400 mini-laptops.</td>
</tr>
<tr>
<td>6</td>
<td>Smart Kigali Program</td>
<td>In 2013, the GoR initiated a smart city program that modernizes the lifestyle of Kigali City dwellers and visitors through use of ICT for better service delivery. This program has already registered success where free Wi-Fi is now provided in public places including commercial buildings, Bus Stations, public transport, hotels etc. For instance, until now, over 485 buses are connected to Wi-Fi and several other public places.</td>
</tr>
<tr>
<td>7</td>
<td>SIM Card Registration</td>
<td>In 2013, GoR completed registering all SIM cards and linked them to national IDs of users in a bid to promote security and efficiency.</td>
</tr>
<tr>
<td>8</td>
<td>Digital Migration</td>
<td>In 2014, Rwanda successfully completed digital migration from analog to digital terrestrial television.</td>
</tr>
<tr>
<td>9</td>
<td>Increased Radio &amp; TV Station Penetration</td>
<td>The number of Radio and TV stations increased from 1 radio and TV stations to 34 and 12 respectively.</td>
</tr>
<tr>
<td>10</td>
<td>Internet Service Providers and Telecom Operators</td>
<td>By Q3 2017, there are 16 registered Internet service providers and 4 Telecom operators.</td>
</tr>
<tr>
<td>#</td>
<td>Achievement</td>
<td>Status</td>
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<td>11</td>
<td>ICT Awareness Campaigns Program.</td>
<td>A local based ICT awareness program dubbed “Korana ubuhanga” was initiated which rotates across the 30 districts. It is an avenue where citizens are informed about existing ICT solutions by vendors. On average, over 100,000 citizens participate in a single campaign and it’s conducted each quarter.</td>
</tr>
<tr>
<td>12</td>
<td>National Cyber Security Authority</td>
<td>With increasing global threats, the GoR is in the process of establishing an institution in charge of cyber security. NCSA has been established and operationalization is currently underway.</td>
</tr>
<tr>
<td>13</td>
<td>Cyber Security Incidence Response Team</td>
<td>In 2010, the Government operationalized a CSIRT team which works 24/7 hour and responsible for surveillance of all cyber threats to respond and prevent/curb incidences.</td>
</tr>
<tr>
<td>14</td>
<td>National Cyber Investigation Center</td>
<td>In 2015, the Government took an initiative to establish a national cyber investigation center within Rwanda National Police. The center has 2 major components including: Cyber Fusion Center - Used to monitor cyber threats and report on crimes and Digital Forensic laboratory - Used for digital investigations, Disc Data Recovery, Mobile forensic and Malware analysis</td>
</tr>
<tr>
<td>15</td>
<td>CCTV</td>
<td>This project has established security cameras across the major sites in Kigali to help monitor incidences and crimes. The CCTV services from different sites are connected to a live-feed central command center.</td>
</tr>
<tr>
<td>16</td>
<td>Public Key Infrastructure</td>
<td>In 2015, GOR established a PKI infrastructure used for authentic access of information on online platforms. Once all the relevant institutions are on board for e-signature, it is expected to cut off most manual processes and promote efficient paperless processes.</td>
</tr>
<tr>
<td>17</td>
<td>Rwanda Online (ROL) Project</td>
<td>In 2014, the Government, through a PPP model, established a dedicated company and digitized all G2C and G2B services. The corresponding online e-Government site, “Irembo,” to date, has 56 e-services and runs a monthly transaction of 1,445,186. However, there are over 150 other online services that are not integrated into Irembo platform. The service access points/agents to help citizens with easy access have also grown to 168,000 Online.</td>
</tr>
<tr>
<td>18</td>
<td>Street Naming integrated with GIS</td>
<td>In 2013, the Kigali streets and houses were given new numbers and migrated to standardized address scheme. The names were also integrated into GIS based maps that are found on Internet.</td>
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<tr>
<td>No</td>
<td>Program Type</td>
<td>Description</td>
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<tr>
<td>19</td>
<td>Automobile Technical control &amp; Speed Governors</td>
<td>The Automobile Technical Control helps to inspect cars automatically and recommends the faults. Also speed control devices were installed in all public vehicles to limit the speed to 60kh. Both projects have been instrumental in reducing and preventing accidents.</td>
</tr>
<tr>
<td>20</td>
<td>Rwanda Information Society Authority (RISA)</td>
<td>In 2017, the GoR established an agency in charge of implementing Cross-Governmental ICT initiatives based on SRMP and other policies.</td>
</tr>
<tr>
<td>21</td>
<td>Video Conferences</td>
<td>Video conference devices were deployed at both central and local government authorities to help conduct online meetings and communications between institutions.</td>
</tr>
<tr>
<td>22</td>
<td>E-Gates</td>
<td>In 2012, Rwanda introduced the e-Gates, which are deployed at the Kigali airport and boarder-ports to facilitate immigration process.</td>
</tr>
<tr>
<td>23</td>
<td>Drone Industry</td>
<td>In 2015, Rwanda was the first country globally to launch use of Unmanned Autonomous Vehicles (Drones) that go beyond the visual line of sight at a commercial scale. Zipline drones operate in health sector delivering blood to patients across all district hospitals. Coordination should be made to expand the use of Drones for other industries to position Rwanda as a leading technology hub.</td>
</tr>
<tr>
<td>24</td>
<td>ID Integration</td>
<td>The National ID has opened APIs to different institutions and now interfaces with more than 18 institutions, which authenticate their services against ID database for smooth and secure processes.</td>
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<tr>
<td>25</td>
<td>Government Command Center</td>
<td>Established in 2014, the GCC helps track in real-time, the key performance indicators of both central and local government.</td>
</tr>
<tr>
<td>26</td>
<td>Smart Classroom Program</td>
<td>In 2016, Rwanda initiated a smart classroom program that digitizes education-learning process. It provides students’ access to computers and basic education software platforms as well as internet access.</td>
</tr>
<tr>
<td>27</td>
<td>Digital Ambassador Program</td>
<td>In 2016, the GoR initiated the digital ambassadors program with partners which aims to train 5 million citizens in the next 5 years (2022) using 500 Digital Ambassadors delivering digital literacy skills to community members, and creating social enterprises, self-employment in the digital economy.</td>
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<td></td>
<td>ICT Sector Strategic Plan (2018-2024)</td>
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<tr>
<td>28</td>
<td>Establishment of centers of excellence</td>
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<tr>
<td></td>
<td>1. Carnegie Mellon University- Africa, a world-class university was officially launched in 2012.</td>
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<td></td>
<td>2. African Institute of Mathematical sciences–Pan African Center of Excellence was established in 2016.</td>
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<td></td>
<td>3. Africa center of excellence for Data Sciences was established at the University of Rwanda in 2016.</td>
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<td></td>
<td>4. Center of Excellence in Internet of Things (IoT) was established at the University of Rwanda in 2016.</td>
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<td></td>
<td>5. An Information Access Center was launched in 2017 with the support of KOICA- NIA.</td>
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<td></td>
<td>6. Establishment of a Center of excellence for Biomedical sciences and e-Health in University of Rwanda is underway.</td>
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<tr>
<td></td>
<td>7. Establishment of an ITU Cyber security center of excellence is currently underway.</td>
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<tr>
<td>29</td>
<td>Girls in ICT Initiative &amp; He for She campaign</td>
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<td></td>
<td>The GoR has a dedicated focus in promoting girls and women through ICT. Several programs have been set forth including Ms. Geek Competition, Tech-Kobwa camps, Tech innovation challenges, and digital financial inclusion through Rugori fund among others.</td>
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<tr>
<td>30</td>
<td>Kigali Innovation City (KIC)</td>
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<td></td>
<td>The KIC provides space for an eco-system of ICT industry and services including academia, operators, incubation centers, companies, innovation centers, financing venture capitalists etc. The project is currently underway with prospects of attracting top talent and FDI.</td>
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<tr>
<td>31</td>
<td>Rwanda Innovation Fund</td>
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<tr>
<td></td>
<td>The RIF has set a target of $100 million for the African young ICT entrepreneurs through venture capital support.</td>
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<tr>
<td>32</td>
<td>KT-Rwanda partnerships</td>
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<td>In 2013, Rwanda signed an agreement with KT to introduce 2 subsidiaries Olleh African Services and Africa Olleh Networks, which focused on Services and 4G roll-out respectively.</td>
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<tr>
<td>33</td>
<td>ICT companies introduced</td>
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<td></td>
<td>Over 68 ICT companies each valued at 350,000 USD were introduced into the market over the years and these have generated Approx. 4997 jobs.</td>
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</tbody>
</table>
### 34. kLab & FabLab

With JICA and RDB support, ICT Chamber established kLab in 2011 as an innovation center for people to turn idea into ICT based solutions and products. It’s a venue that connects, nurtures, and introduces potential entrepreneurs to ICT opportunities.

FabLab is an open digital manufacturing/maker space which enable prototyping/modeling using digital tools. It was established in 2016 with partnership between GoR, JICA, MIT, SolidWorks, and ICT Chamber. The Lab caters for people with aspiration to create products and prototypes and turn them into viable businesses.

### 35. Northern Corridor Integration Projects

The NCIP framework brings together partner states Uganda, Kenya, Rwanda and South Sudan. An ICT cluster collaboration has enabled realization of transformative projects including One Area Network, Cyber Security, E-Services among others.

### 36. The Smart Africa Alliance

In 2015, The Smart Africa Alliance established its headquarter in Kigali. It provides a forum for African countries, collaborating in making smart investments for accelerated socio-economic development. Smart Africa launched in 2017 the Smart city blueprint for Africa that is expected to guide African cities to plan accordingly.

### 37. Guiding policies

- **Smart Rwanda Master Plan** – The principal ICT sector strategy and plan that guides the overall National ICT for development initiatives. It is the last of the NICI Plans and will come to fruition in FY2020.
- **Broadband Policy** – Puts in place a policy and implementation framework for universal broadband access in Rwanda.
- **Cyber Security Policy** – Establishes a policy and operational framework to ensure Rwanda’s cyber resilience.
- **Data Revolution Policy** – Sets an agenda to open data and conduct big data analytics.
- **Digital talent Policy** – Sets a mechanism to train all Rwandans to be a digitally literate population by focusing on 3 layers: the top experts (elite), professional skills for workers and basic literacy for citizens.
- **E-Waste Policy** – E-waste puts up a business framework to manage and recycle all electronic materials for better conversation of environment but also for creating more jobs.
ICT Sector Strategic Plan (2018-2024)
Ministry of Information Technology and Communications

• **ICT4AG Strategy** – The agriculture sector elaborated an ICT strategic plan aimed at position ICT to accelerate production and reducing the cost of doing business.

• **ICT4ED Strategy** – The ICT in Education Master Plan was elaborated to set a framework for mainstreaming ICT in the entire learning process of students at all levels.

• A number of other policies mainly Women empowerment strategy, e-commerce are currently underway.

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<table>
<thead>
<tr>
<th>37</th>
<th>Global rankings</th>
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<tbody>
<tr>
<td></td>
<td>Rwanda ranked 1st for Continental Social Media Award (Social Media Awards Africa-SMAA Report 2015).</td>
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<tr>
<td></td>
<td>Rwanda ranked 2nd in Africa for ease of doing business (World bank Report 2015).</td>
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<tr>
<td></td>
<td>Rwanda ranked Number 3 among Competitive Economies (World Economic Report 2015).</td>
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<td>Rwanda ranked number One in Open Data in Africa (Open Data Institute Report 2016).</td>
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Table. Annex.7.1: ICT sector status and achievements
**Appendix C**

ICT Development Index (IDI) indicators (ITU, 2016)

<table>
<thead>
<tr>
<th>ICT access</th>
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<tbody>
<tr>
<td>1. Fixed-telephone subscriptions per 100 inhabitants</td>
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<tr>
<td>2. Mobile-cellular telephone subscriptions per 100 inhabitants</td>
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<tr>
<td>3. International Internet bandwidth (bit/s) per internet user</td>
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<tr>
<td>4. Percentage of households with a computer</td>
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<tr>
<td>5. Percentage of households with internet access</td>
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<tr>
<th>ICT use</th>
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<tbody>
<tr>
<td>6. Percentage of individuals using the internet</td>
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<tr>
<td>7. Fixed-broadband subscriptions per 100 inhabitants</td>
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<tr>
<td>8. Active mobile-broadband subscriptions per 100 inhabitants</td>
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</tbody>
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<th>ICT skills</th>
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<tbody>
<tr>
<td>9. Mean years of schooling</td>
<td></td>
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<tr>
<td>10. Secondary gross enrolment ratio</td>
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</tr>
<tr>
<td>11. Tertiary gross enrolment ratio</td>
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