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Health Indicators, Human Capital and Economic Development in Sub-Saharan Africa: the case of Rwanda

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INTRODUCTION AND ABSTRACT

The inspiration for the chosen topic of this thesis comes from two sources that could not be more different.

The first one is a NBER working paper published in 1996 by the MIT press and written by the economist Robert J. Barro: "*Determinants of Economic Growth: a cross-country empirical study*". In the paper the empirical results for a panel of one hundred countries are exposed: the aim is to understand, for a given starting value of per capita GDP, which variables are able to enhance its growth rate. The neoclassical model is extended and incorporates government policies and exogenous variables linked to the living standards of citizens, such as, for example, human capital, schooling rate, fertility decisions and diffusion of technology.

The second source is instead a paragraph of a paper written by Menekse Gencer and published in 2011. The paper is titled "*Mobile Money Movement: Catalyst to Jump-Start Emerging Markets*" and is dealing with the development of the mobile money industry and its effect on emerging markets. In particular, in examining the mobile money business in Kenya, the author is mentioning a study carried out by the CGAP (a global partnership of 34 leading organisations that seeks to advance financial inclusion) saying that "*for the first time, Africa is becoming a bigger lure for investors than for aid donors. Africa's poverty rate has been declining by 1 per cent annually since the 1990s, and investment is growing dramatically. A decade ago, Africa was receiving less than 5-billion (U.S.) in foreign investment annually. By 2008, it was attracting nearly 40-billion in direct foreign investment – more than it received in foreign aid. One survey found that 40 per cent of emerging-market equity investors are putting money into Africa today, compared with 4 per cent in 2006.*"

It is often very difficult to understand and quantify what is happening in the African continent from the economic and social point of view and for a western observer is surprising to consider Africa as the next target for foreign investors.

For this reason I have decided to analyse what has happened in one specific African country, Rwanda, which is one of the most interesting reality of the Sub-Saharan area.

The country, located in the Great African Lakes region is mainly known for the dramatic historical events of the early nineties, when almost 20% of the population was killed during the Rwandan genocide.

The study is aimed to understand how the policies implemented after the genocide of 1994 have influenced the economic path of the country and determined the impressive growth of the last two decades.

In the first chapter the history and economic background of the country, leading to the dramatic events of 1994 will be analysed. The second chapter will deal with the post-genocide restructuring through the analysis of the document Rwanda 2020. The third chapter will focus on the current economic situation and health-related improvements in the country in order to highlight the achievements reached in the two fields.

Finally the last chapter will deal with the creation of an econometric model aimed to assess how the policies and goals identified in Rwanda 2020 have contributed to the sustained economic growth.

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Chapter 1

Rwanda: country overview

1.1 Geographical Features

FIGURE 1.1: Rwanda in the African continent

The Republic of Rwanda is located in the Central Africa Great Lake Region, bordering the Democratic Republic of Congo to the west, Uganda to the north, Tanzania to the east and Burundi to the south. It is therefore landlocked, with a distance of 1500 kilometres from the Indian Ocean and of 2000 kilometres from Atlantic coast. Often described as "the Land of Thousand Hills", the country's main geomorphological features are the mountains and highlands of the watershed between the Nile and Congo river basins and the presence of many lakes, the largest being Lake Kivu, at Rwanda western border. The central and western part of the country is dominated by mountains, part of the Albertine branch of East African Rift: the highest peak

is reached in the Virunga volcano chain, with the 4507 metres of Mount Karisimbi. Although the country is situated just below the Equator, due to the high altitudes that serve as climate moderator, Rwanda has a temperate tropical highland climate, able to support between two and three agricultural seasons per year, a potential unparalleled by most African countries.

FIGURE 1.2: Great Lake Region

1.2 Social Features

1.2.1 Demographics

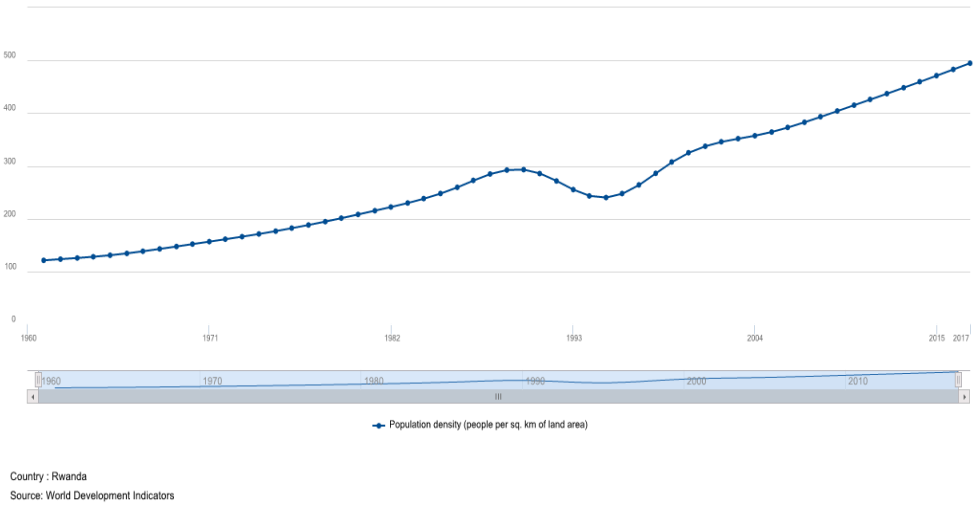


FIGURE 1.3: Population Density

The data concerning population and population growth for Rwanda highlight a high population density. In 2016 the country had a total population of 12.2 million, while in 1991, before the

genocide, it was around 7 million: even after the genocide, in 1995, with 5.93 million, it was the highest population density in mainland Africa. In fact, population density in 2017 was 494.9 per square kilometre of land, but excluding lakes, national parks and forest reserves the value is even higher. The reasons for Rwanda's high population density can be found in the peculiar land and climate and in the fact that the mountainous area has been protective against hostile intruders. The geomorphology of the country together with its efficient military structure made it safe from the razing incursions of Arab and European slave traders: as a result the population didn't decrease, but it was instead increased by the flow of people that sough for a refuge. These, together with the strong influence of Catholic church against birth control measures, are the main explanatory factors for the peculiar demographic pressure in Rwanda, considered by many analysts, as one of the trigger of the catastrophic events of 1994. The total population and

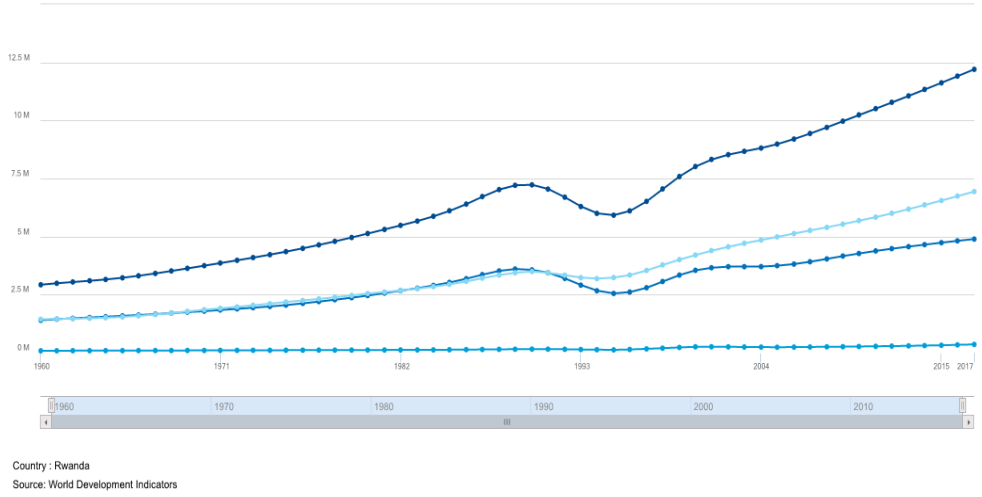


FIGURE 1.4: Population Age Distribution

the share of population between 0 and 14 years, 15 and 64 years and over 65 years are plotted in figure 1.4. The line representing the population over 65 years lies far below the others, due to the low life expectancy that was, in 1991, around 30 years. Moreover, especially before the genocide, the share of population between 0 and 14 is almost equal to the share of population between 15 and 64. Is estimated that, before the genocide, 90,4% of the population was Hutu, 8,2% was Tutsi and 0,4% was Twa. Another interesting data concerns the distribution of rural and urban population: the higher share of population lives in the countryside and two-thirds of the urban population are concentrated in the capital, Kigali. More than the 20% of the adult urban population, according to the census of 1991 contracted HIV virus, while the larger part of rural population was suffering from endemic disease and water-related disease, worsen by the lack of access to health services, potable water and sanitation. Thus, data depicts Rwanda as

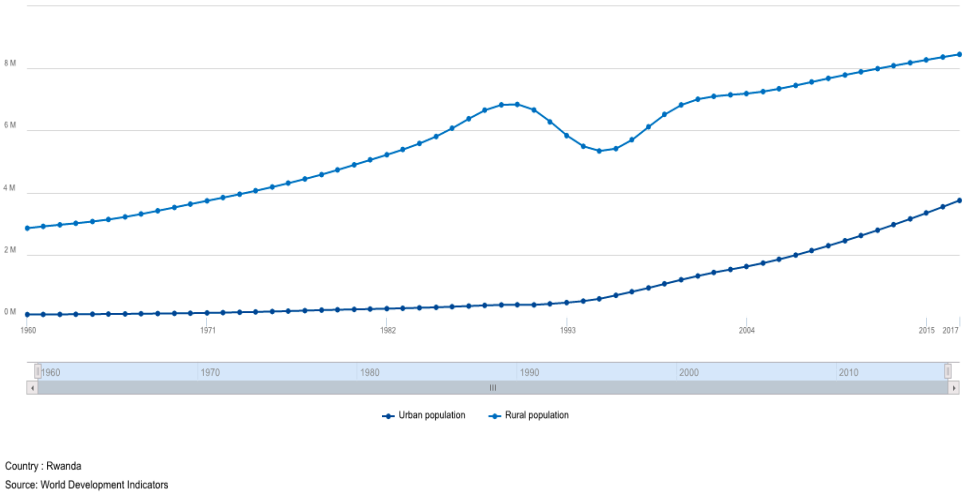


FIGURE 1.5: Urban and Rural population distribution

a rural country, whose population farm on hills, where every hill consists in several *ingo*, an agglomeration of *rugo*, defined as the family enclosure, "the basic unit of social life in Rwandese society". Almost the 93% of the labor force, before the genocide, was employed in the agricultural sector, that had to absorb the high annual increase of working population and rapid demographic growth. This issue translated in a consistent problem related to the use of land: in 1984 57% of rural households, on average composed of five people, were farming less than 10000 square metres, 25% less than 5000 square metres. Given the significant increase in population growth and the laws concerning inheritance and right to use land, the size of the holdings continued to fall: in the early nineties, on average, a Rwandese household was farming at least five plots of land and had to make with it a constant supply of food throughout the year. Is estimated that, in order to preserve the fertility of soil, farmers were growing up to 14 different crops in almost 50 rotations: the system implied highly sophisticated decisions and was difficult to maintain and the results were the decrease of soil fertility and the introduction of short-term strategies such as farming on slopes, with the high risk of seeds being washed away from rainfall. The consequence for the Rwandese rural population was malnutrition and deeper poverty.

1.2.2 Economy

Before the war started in 1992, Rwanda was experiencing in the late 1980s a worsening in every key area such as GDP growth, balance of payments, trade and indebtedness and balance of payments, with a value of imported goods 3.5 times higher than the value of exported ones. The main causes of this economic collapse can be found in the coffee market crisis and in

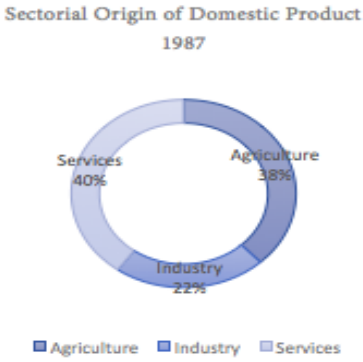


FIGURE 1.6: GDP Composition 1987

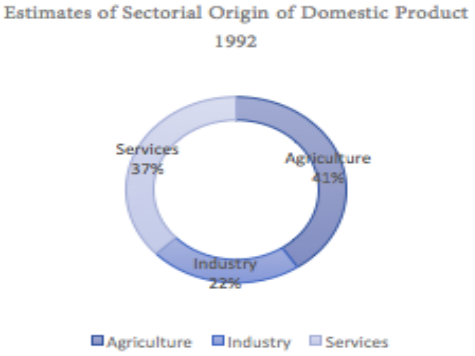


FIGURE 1.7: GDP Composition estimates 1992

the consequent decline in the country international purchasing power. As highlighted above,

Table 5: Foreign trade (Rwfr millions)

	1988	1989	1990	1991	1992	1993*
Merchandise exports fob	8,291	7,635	9,224	11,598	8,917	6,404
of which:						
coffee	6,544	4,691	6,108	7,210	n/a	n/a
tea	1,082	1,557	2,031	2,797	n/a	n/a
tin	0	381	287	320	n/a	n/a
Merchandise imports cif	28,280	26,642	23,059	38,454	38,263	35,861
of which:						
petroleum	3,647	3,550	3,885	4,555	n/a	n/a
Trade balance	**-19,989**	**-19,007**	**-13,835**	**-26,856**	**-29,346**	**-29,457**

* *January–September.*

Source: IMF, International Financial Statistics.

FIGURE 1.8: Foreign Trade

Rwandese economy is mainly based on agriculture: Rwanda has very limited natural resources and the economy, before the genocide, was mainly based on two cash crops, coffee and tea. The most significant cash crop for the country is definitely coffee, that is grown in the variety arabica

Table 8: External debt ($ millions unless otherwise indicated)

	1987	1988	1989	1990	1991	1992
Total external debt	**606.1**	**654.5**	**644.3**	**736.2**	**833.1**	**873.3**
Long-term debt	559.8	609.3	598.9	687.8	768.7	804.3
Short-term debt	39.3	41.5	44.5	48.3	51.9	56.9
of which:						
interest arrears on						
long-term debt	0.3	0.7	0.9	2.8	4.5	7.6
Use of IMF credit	6.9	3.7	0.9	0.1	12.5	12.0
Public & publicly guaranteed						
long-term debt	**559.8**	**609.3**	**598.9**	**687.8**	**768.7**	**804.3**
Official creditors	548.5	601.9	593.9	684.1	766.1	802.8
Multilateral	390.6	436.3	478.2	542.2	612.6	646.5
Bilateral	157.9	165.6	115.7	142.0	153.5	156.3
Private creditors	11.3	7.4	5.0	3.7	2.6	1.5
Total debt service	**23.8**	**22.7**	**29.0**	**21.6**	**25.3**	**24.4**
Principal	14.2	11.6	16.6	10.3	13.0	11.6
Interest 9.6	11.1	12.3	11.3	12.3	12.8	
of which:						
short-term debt	2.4	2.8	4.8	5.2	5.6	6.1
Ratios (%)						
Total external debt/GNP	29.8	30.8	27.2	33.2	51.4	55.4
Debt-service ratio*	13.3	12.9	18.4	14.4	17.7	n/a
Short-term debt/total						
external debt	6.5	6.3	6.9	6.6	6.2	6.5
Concessional long-term						
loans/long-term debt	97.7	98.6	99.0	99.2	99.5	99.7

Note. Long-term debt is defined as having original maturity of more than one year.
* *Debt service as a percentage of earnings from exports of goods and services.*
Source: World Bank, World Debt Tables.

FIGURE 1.9: External Debt

on the world market. The crop was introduced by the Belgian administration in the first decade of 1900: after the introduction, coffee cultivation was made compulsory in many areas and peaked in 1986, when it accounted for 82% of Rwanda's total export earnings. In 1989 there were almost 700000 smallholders coffee producers. In the 1980s the Government was assuring a guarantee price of 125 Rwanda francs per kilos, making huge profits from coffee trade. The situation

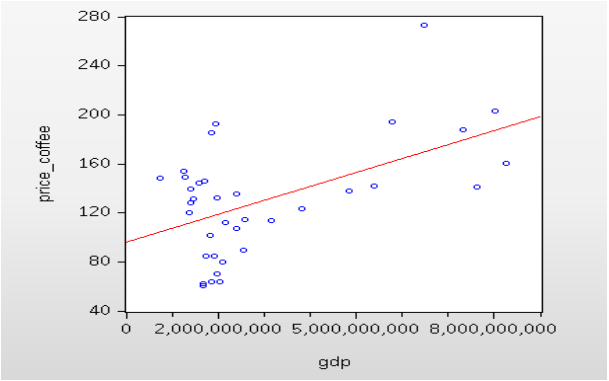


FIGURE 1.10: Scatterplot of coffe prices and Rwanda GDP

changed in the 1990s: the first event that hit severly Rwandese coffee market was the collapse of the International Coffee Agreement of 1989. The International Coffee Organization was unable to agree on export quota, due to the shift in consumers' tastes towards higher quality coffee at expenses of traditional varieties such as robusta. Brazil, the most important and powerful coffee producer, refused to reduce its quotas, fearing a decrease in market share, leading to the breaking of the previous 1983 International Coffee Agreement. In 1991 coffee production was accounting for 51% of of Rwanda total export earnings: the restructuring was inevitable. Rwandese farmers increased the production significantly between 1989 and 1990, only to earn 20% less: in fact the

Government cut the guarantee price to 115 Rwanda francs per kilos and at the same time the Structural Adjustment Program leaded by the International Monetary Fund devalued national currency by 40%. An important consequence of the coffee market crisis was the development of the tea market, rising from 9% of of exports in 1989 to 30% in 1992. Tea cultivation was different from coffee one: tea was primarily grown in big estates, mainly government-owned.

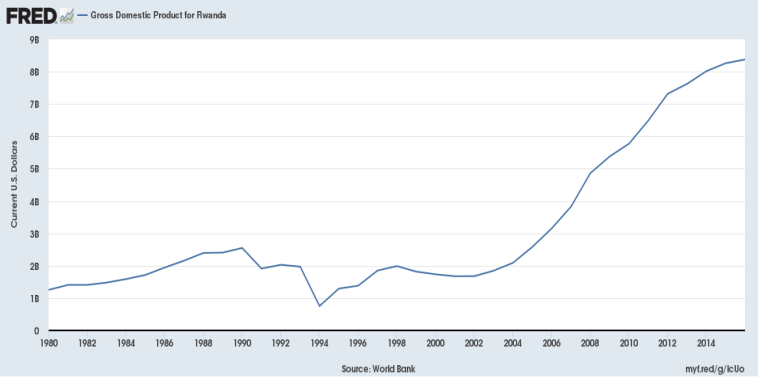


FIGURE 1.11: Rwanda Gross Domestic Product

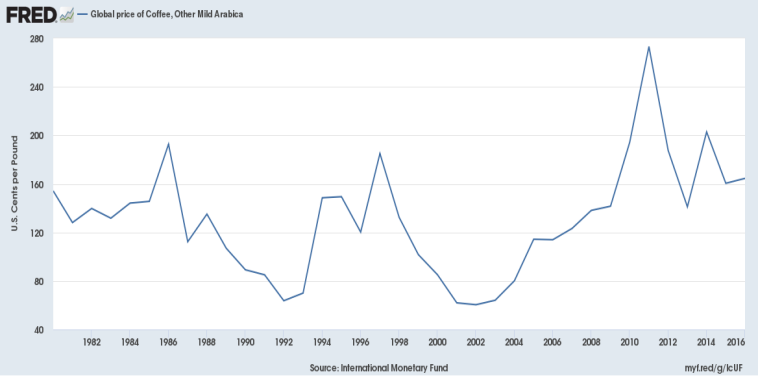


FIGURE 1.12: Global price of coffee for other mild arabica

According to many analysts there is an even stronger link between the global coffee market and the factors that contributed to the production of the genocide. When in 1927 the colonial authorities in Rwanda started the aggressive promotion of coffee production they used Tutsi as chiefs and sub-chiefs, due to their "traditional authority". On the agricultural class, mainly composed by Hutu, had to pay *ubureetwa*, the labor tribute replaced with taxation in 1949. Hutu were therefore forced to pay taxes and at the same time to work on private plantations owned by local chiefs: by mid century this situation of forced labor, asymmetrical accumulation of resources had exacerbated the already critical ethnic segregation. An important episode for the later history of the country happened in 1956, when Catholic Church, aimed to help the impoverished Hutu farmers, gifted them with a hectare of land in order to establish the coffee production cooperative Trafipo (Travail, Fidélité, Progrés), which provided important economic

and leadership opportunities for the Hutu elite: in 1957 Gregoire Kayibanda, the eventual first president of the country, became head of Trafipro. The Hutu educated class was successfully mobilizing around ethnicity, and in 1961 80% of Rwandese population voted for the end of the Tutsi monarchy followed in 1962 by the won of Kayibanda party, but the social and political inequality was almost unchanged. As the global price of coffee increased, the Hutu elite was consolidating control over the coffee production, with the transformation of Trafipro, located in the southern part of the country, into a state-run marketing board, an operation that northern producers saw as a major cause of regional bias among Hutu elites. The reaction of the president Kayibanda was the articulation of Tutsi as common enemies: the resulting climate of instability and violence created the conditions in which, supported by northern Hutu elites, the general Juvènal Habyarimana seized power in July 1973. The new president, aimed to gain the support of Western countries and international investors, instituted a series of economic reforms known as "planned liberalism" that made possible for the country to receive large sums of foreign development aid and increase both GDP both human capital index. Habyarimana restructured the domestic coffee economy, introducing coercive and non coercive incentives for farmers to convert their land to coffee production: the Rwandex, the Government's marketing board, was able to increase the coffee purchase price from 60 to 120 Rwandan francs. While coffee was funding increasingly larger percentage of the state budget, the consistent gains were never well reinvested and even the price stabilization fund was a victim of this profound corruption, leaving no security net: the surplus was used in order to mute the regional conflicts between the ruling Hutu class. Another issue created by the increased coffee production was the trade off with food production, that jeopardized Rwanda's food security, already damaged by the National Food security strategy that led to the ban of all food imports in 1988, in order to increase the country's self sufficiency. In 1989, the country was hit at the same time by drought and by the fall of coffee prices due to the failure of the International Coffee agreement: the absence of food resources led to a deadly famine that killed hundreds and forces more than 10000 refugees, mainly Tutsi, to Burundi or Tanzania. The fall in the sales of coffee resulted in a considerable increase in national debt, that peaked to one billion in 1994, with the consequent intervention of the International Monetary Fund and the devaluation of the Rwandan franc. The economic stresses caused by the heavy fluctuations of global coffee prices lead to the bankruptcy of state-owned enterprises and the collapse of health and education services, laying the foundation for the dramatic genocide of 1994.

1.3 History

1.3.1 Pre-Colonial Period

The history of pre-colonial Rwanda is important in order to understand the evolution of ethnic diversity, and its impact on the dramatic events of 1994. According to many historians the original inhabitants of Rwanda were a hunter-gather population that also practised pottery and basketwork, ancestors of the small minority of Twa. The Hutu arrived in the area almost 3000 years after the Twa population, in the migration called Bantu expansion, and began to displace them. The Hutu were mainly farmers and were organized in *statelets*, each of them dominated by clan and headed by a *mwami* (chief or king). Rwanda as the geo-political entity of many statlets was born, according to historians, between the 11th an the 15th century, when the settlement of Tutsi started, in the frame of a large pastoralist migration southward into the Great Lakes region. The migrations have been mainly a process of gradual and peaceful infiltration, in which Tutsi were assimilated by Hutu taking over their language (*kinyarwanda*) and incorporated their traditions and cults. In pre-colonial period, Tutsi, Hutu and Twa roughly corresponded to occupational categories: on one hand cattle-helders, administrators and soldiers were Tutsi, while farmers were Hutu. The mobility between the two groups was mainly dependent on the economic fortune of the individual. People themselves identified each other according to clan affiliation rather than to being Hutu or Tutsi. The aggregate of *statelets* became the united Rwanda only in the second part of 19th century, under the *mwami* Kigeri Rwabugiri, that represented all authority in a politically-centralized state. The reign of Rwabugiri lasted from 1860 to 1895 and was marked by the extention of the central power to the peripheral areas of Rwanda and the centralization of the state authorities, that contributed to sharpen and rigidify the categories of Hutu and Tutsi. The basis of Rwandese society before colonization was the *ubuhake*, a patron-client relationship between individuals belonging to two different social classes: the relationship involved reciprocal loyalty and exchange of goods and services. Mostly the patron was Tutsi, while the client was a Hutu or a Tutsi of inferior social status. The persistence of *ubuhake*, that was particularly strong in the central part of the country, had the effect of institutionalize the differences between Hutu and Tutsi, being the first ones farmers and the second cattle-breeders, legitimate a process of ethnic dichotomy and consolidate the formation of a Tutsi dominated structure.

1.3.2 Colonial Period and Independece

Rwanda became a German colony after the Berlin conference of 1884 as part of the German East Africa, a large part of the Great Lakes region. including present-day Burundi, Rwanda and part of Tanzania. In 1916 the territory was occupied by Belgium, as a result of the World War I campaign against Germany. The country, both with Belgians both with Germans, experienced just a marginal external administration, since the existing system of *mwami* kingdoms was one of the most efficient of the region: the occupation came through protectorate "treaties" negotiated between the existing political system. The situation changed after the First World War when the League of Nations mandated Belgium to administer Rwanda: the Belgian administration had as an effect the distortion of the indigenous pre-colonial *ubuhake*: the patron-client relationship became more rigid and was reinforced getting rid of the typical element of reciprocity. The effects were the introduction of forced labor and the exacerbation of the socio-economic dichotomy between Hutu and Tutsi. The phenomenon can also be linked to the diffusion of the so called "Hamitic thesis", according to which "everything valuable in Africa has been introduced by Hamites, supposedly a branch of Caucasian race". European exploited the thesis because it allowed to link physical features to mental capacity and to a "natural born leadership": in Rwanda Hamites were Tutsi. The racist thesis therefore considered Tutsi related to European and therefore easier to work with: the result was a process of "Tutsification", in the 1930s the monopoly of political and administrative power was in their hands. The Hamitic thesis was also endorsed by the catholic church and its action through catholic schools, that represented the dominant education system during the colonial period: the educational policies openly favoured Tutsi and discriminated against Hutu, that were taught only the education required for working in mines and in the industry. The process of "ethnogenesis" also reflected on the political demands: the opposite thesis were expressed in three different documents, on one hand the Hutu position produced the *Bahutu Manifesto* in March 1957, while the Tutsi positions were explained in two letters by the Tutsi chiefs. The Hutu manifesto laid the foundations for the for the revolution of 1959, stating that Tutsi were foreigners and that the majority of Rwandese, Hutu, were the rightful rulers of the country. The political parties were therefore established along ethnic cleavage: *Parmehutu (Parti du mouvement de l'émancipation des Bahutu)* and *Aprosoma (Association pour la promotion sociale des masses)* were Hutu, while *UNSAR (Union Nationale Rwandese)* and *RADER (Rassemblement Dèmocratique Rwandais* were Tutsi. The political turmoil led to the so called *peasant revolution* of 1959, that, with the support of Belgian administration led to the abolition of monarchy and elimination of the traditional political and

administrative Tutsi structures. The main cause of the revolution has been the intransigence of the conservative administrative elite, which opposed to the democratization asked not only by Hutu elite, but also by a more progressive part of Tutsi. The initially almost peaceful revolution evolved in violent clashes when the Tutsi-led traditional administrative elite tried to maintain its authoritarian power: with the support of the Belgians the revolt abolished the monarchy, declared independence and marked the rise of a Hutu elite. In the parlamentary elections of September 1961 the Hutu parties scored 83% of the votes, corresponding almost to the proportion of Hutu among the population, while the Tutsi one merely 16%. The Belgian authorities had a crucial role in the revolution outcome: influenced by the winds of change towards democratization over Africa, they started giving their support to Hutu, abandoning the policy of indirect rule carried out through the *mwami* structure. When the ethnic violence broke in 1959, the Belgian government sent troops to the country, but not aimed to crush the peasant revolution, but supporting the Hutu party appointing more than three hundred Hutu chiefs and sub-chiefs and endorsing national independence through the granting of international autonomy under a government led by the founder of the Hutu party *Parmehutu* Grègoire Kayibanda, elected President by the new parliament in October 1961. The events of 1959-1961 determined a crucial change in the status quo for Tutsi causing on one hand a huge number of refugees and on the other their exclusion from public life: Tutsi Rwandese had become the target of a worsening series of violent actions whose first victims were chiefs and sub-chiefs. With the election of the first president, the multi-partyism ended and Rwanda became de facto a single-party state, where leading party *Parmehutu* became the national party and achieved the elimination of the opposition through intimidation, arrest and physical violence. In 1973, certainly under the influence of the dramatic event of 1972 in Burundi where Hutu were victims of genocide killings, ethnic violence exploded in Rwanda leading to the coup of 5 July 1973, when Kayibanda's regime ended marking the beginning of the second republic under the President Habyarimana. The so called second republic sharply contrasted with the austerity of the first one: it was a period of distinct modernization characterized by opening towards the outside world, urban growth, investment and business. The road network, telecommunications and electricity grid improved, and the country witnessed a gradual and increasing urbanization with the capital, Kigali, reaching 250000 inhabitants in 250000 compared to the 15000 of 1965: the gap between town and countryside (which, however, had always constituted an important element of equilibrium and cohesion) began to crumble. The successful policies of the second republic are reflected in the increase of the gross national product per capita, that, despite the specific features of the Rwanda (land-locked nature, demographic pressure and lack of raw materials),

was the most successful one in comparison to the other countries of the Great Lake region, had an efficient system of infrastructures and telecommunications, an adequate water supply and electricity grid. The situation was also remarkable economic terms: the economy was in balance, the currency quiet stable and in 1987 Rwanda's debt amounted to 28% of GNP, one of the lowest percentage in Africa.

Year	Ranking				
	Rwanda	Burundi	Zaire (now Dem. Rep. Of Congo)	Uganda	Tanzania
1976	7	11	16	33	25
1981	16	14	12	13	19
1985	18	11	9	n.a.	21
1990	19	11	12	13	2
Difference 1976-90	+12	0	-4	-20	-23

FIGURE 1.13: GNP per Capita in Rwanda and Neighbouring Countries

1.3.3 The 1990-1994 Crisis

The most dramatic years for Rwanda started in 1990, when the military wing of the Rwandese Patriotic Front began to invade the northern part of the country: the invasion, started in October 1994 and the consequent escalation of violence, culminated with the shooting down of the airplane that was taking the President back from a peace meeting in Tanzania and the genocide of 1994. The Rwandese Patriotic Front (RPF) was born in 1998 in Kampala, Uganda and consisted in a highly motivated and well trained military force. The RPF was created by the over 600000 Tutsi refugees that fled Rwanda after the peasant revolution, between 1959 and 1966. The main aim of the RPF was the solution of the refugee crisis, but the Front was also working on a political program accusing the Hutu-lead Rwandese government of undemocratic and corrupted practices and ethnic discrimination. On the other side, the Habyarimana regime, whose main pillar were the Hutu party *Mouvement Révolutionaire National pour le Développement (MRND)* and its army, enjoyed considerable popularity both in the Hutu, both in the Tutsi community until 1985, when the country was hit by a deep economic crisis. The authoritarian one party government was able to transform the small and landlocked country in one of the most healthy and self-sufficient of the area: the average inflation rate in the 1980s never exceeded 4% per annum, despite the average Sub-Saharan rate of 20% and the GNP per capita growth was one point higher than that of the Sub-Saharan Africa. This situation allowed Rwanda to gain

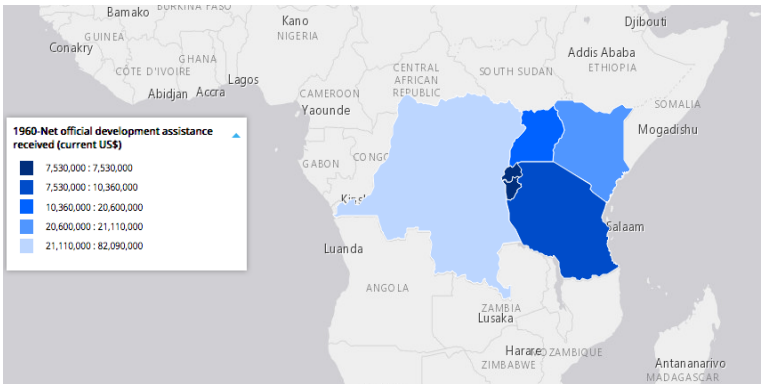


FIGURE 1.14: Development aids in Neighbouring Countries

substantial support from multilateral agencies, bilateral donors and NGOs. Several problems

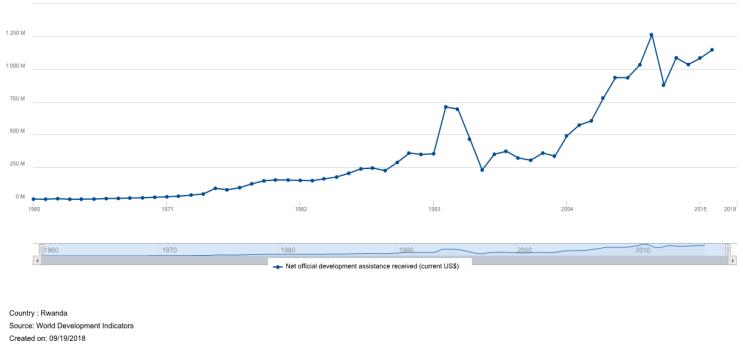


FIGURE 1.15: Net official development assistance received by Rwanda

however did develop: the demographic pressure was very high and families faced increasing difficulties in producing sufficient food for their needs. If in 1982 9% of the population consumed less than 1000 calories a day, living therefore in extreme poverty level, the percentage increased to 15% in 1989 and reached 31% in 1993, due to the famine that hit the country. Rwanda was therefore becoming more and more dependent on food aid. The situation was made worse by the sever drought happening in 1989-1990, that recurred in 1991 and 1993 and by the disease that affected two staple crops, cassava and sweet potatoes: the result was half million Rwandese facing malnutrition and food shortages. In 1985 moreover, Rwanda had to close its last tin mine due to increasing costs, mismanagement and collapse in world prices: tin was contributing for 15% to export earnings. The other economic shock that contributed to the turmoil was the failure of ICO and the consequent drop in the prices of coffee, explained in section 1.2.2. The international community was generous in responding to Rwandese crisis: from 1989 to 1991 the international aid increased of 60%. In September 1990 Rwanda signed with the IMF a structural

adjustment programme which amounted to 216 million of dollars. The programme suggested a wide range of policy measures that can be summarized as follows:

- *macroeconomic stabilization and improved international competitiveness through:*
  - devaluation of the Rwandese franc in order to maintain a competitive exchange rate
  - reduction of government budget deficit to 5% of GDP in 1993 from the 12% level of 1990
  - import liberalization and elimination of controls and regulations on domestic prices and private sector
  - liberalization of the interest rate structure
- *reduction of the role of the state in the economy, to be achieved through the reduction of guaranteed price to coffee producers and privatization of 12 of the 86 public enterprises*
- *introduction of a so called "social safety net" through a "Social Action Program"*

Two key measures of the programme were not implemented: the elimination of subsidies to coffee producers and the cut to the budget deficit. The government reduced the guarantee price from 125 RWF per kilo to 100 RWF per kilo in 1990, but then it unilaterally increased it to 115 RWF in 1991. The budget deficit on the other side, that rather than falling, increased to 18% of GDP in 1992 and 19% in 1993. Therefore the second tranche of the World Bank structural adjustment credit was not provided. Moreover the windfall that raised from the devaluation of the Rwandese franc was never invested in relevant welfare measure towards peasant farmers dealing with the coffee price crisis, but was rather invested in military spending, that quadrupled from 1989 to 1992, from 1,9% to 7,8% of GDP. The one party state of president Habyarima was therefore facing a difficult economic situation made worse by the increasing opposition of the RPF and by rumors of corruption within the regime: in the early 1990s several protests demonstration and strikes were held, mirroring the increasing discontent and asking for democratization through the introduction of a multi-party political system. Given the economical, political and structural pressures that the regime was facing, twenty days after the RPF invasion of 1990, under the mediation of Belgian and Tanzanian officials, the President Habyarimana and the President of Uganda, Museveni, met in Tanzania, in a OAU (Organization of African Unit) and UNHCR supervised regional conference, in order to deal with the huge refugee problem that the country was facing. They also agreed on direct negotiation with the RPF, that was therefore recognized

for the first time by the President as a discussion partner. it was the start of the so called Arusha Negotiations. The talks started in July 1992 lasted until June 1993 when an accord was reached. The final agreement envisioned the following measures:

- the creation of a rule of law according to which Rwanda should follow the principles of national unity, democracy, pluralism and human rights, assuring to all citizens the same rights independently from their ethnic, regional, religious or sexual identity. The implementation of the rule of law would have led to the elimination of the quota system, that attributed power and positions according to the ethnic identity.
- the creation and enlargement of a transition government, including RPF and a national parliament composed of eleven members each from MRND, MDR, PSD, PL AND RPF, four members from PDC and one member each from the other recognized party. The agreement was therefore envisioning the end of the single-party system. The president Habyarimana would have remained the head of the state, but would have had to share power with the Prime Minister and the Government: presidential and parliamentary election were to be held at the end of the period of transition. The main implication of this part of the treaty was therefore the need of concurrence of at least four party in order to reach the majority vote.
- the reintegration of the 1000000 Tutsi refugees in the country
- the creation of a national unified army, merging the RPA and the FAR (Rwandan armed forces)

In order to assure the implementation of the treaty the United Nations Security Council established the United Nations Assistance Mission for Rwanda (UNAMIR), that was aimed to assist the implementation of the Arusha Accords with the presence of 2,548 soldiers, mainly Belgians.

1.3.4 April 1994: Rwandan Genocide

At the end of Arusha consultations, Rwanda was facing a dangerous climate of political uncertainty, worsen by the dramatic economic condition and by ethnic polarization strongly fueled by media that incited violence against Tutsi and moderate Hutu. The casus belli that triggered the Rwandese tinderbox happened on April 6 1994: the airplane with abroad the President

Habyarimana and the President of Burundi Ntaryamira, was hit by a rocket and exploded while approaching Kigali airport. They were travelling from a meeting in Dar-es-Salaam, Tanzania, where the implementation of Arusha treaties had been discussed and signed. Few hours later one of the worst violences in the history of humankind started: in less than three months, known as the hundred days of Rwanda, betweeen 500000 and 1000000 people were killed. The massacre, implemented in a meticulous way, was planned by members of the Hutu extremist elite and high officials. The violence started right after the plane crash with a selective assassination of opposition politicians, mostly Hutu opposing the party in power. The second target group was dissenting civilians, both Hutu and Tutsi, including journalists, human rights activists and representatives of non-governmental groups. Then, the generalized massacre of Tutsi started: soldiers, police and militia erected checkpoints and barricades to screen ID cards, that contained ethnic classification. An estimated 500000 to 1000000 Rwandans were killed, constituting an estimated 70% of the Tutsi population. Women and children were not spared: rape was used as weapon of war, causing a massive diffusion of HIV infection. The international institutions were caught unprepared when the massacre broke out, a probably didn't realize the dimension of the tragedy that was happening in the rural areas, far from the eye of the media. According to historians and international observers, the final solution against Tutsi was first planned when the consultations between the President and RPF started, in 1990: the army began arming civilians with weapons, mainly machetes, and training Hutu youth in combat, officially as a program of "civil defence" agains RPF. Rwandese purchase of grenades, munitions, machetes and other agricultural tools, that ended up to be weapons during the massacre, increased significantly in the 1990s. Despite that the international community wasn't able to meet expectations and mainly dealt with the evacuations of foreign nationals. In July 1994, finally, the RPF leaded by General Paul Kagame took over the leadership of the country. Rwanda was in shock and in complete economic and social disruption. The massacres and war had provoked massive population movement, with two million Rwandese moving to neighbouring countries and one millions becoming internally displaced.

Chapter 2

Aftermath of the Rwandan Genocide: a vision to rebuild the country

In July 1994, when the RPF took the power and ended the dramatic flow of violence now internationally recognized as Rwandan genocide, the economy and the social situation were devastated. The healing process that took place in the following twenty-two years after the massacre made of Rwanda one of the most promising country of the Sub-Saharan Africa, and is often defined by international observers as "Rwandan miracle". The country has experienced, between 2001 and 2014, a GDP growth of almost 8% per year, becoming one of the fastest growing economies in Africa. The most impressive achievements of Rwanda are however to be found in the human development field: the country was able to cut the percentage of people living below the poverty line from 57% in 2005 to 45% in 2010 and to reduce inequality and gender gap, accounting for one of the highest percentage of women in parliament (64% compared to 22% worldwide). The impressing achievements of the country are led by the President Paul Kagame, de facto leader since the end of the genocide, in 1994. The development and healing process aimed to restore the economy and social situation of the country started at the end of the 1990s, with a national consultation process that produced in 1998 the so called Vision 2020. The government development program consists in a list of goals to be achieved before 2020 and aimed to make of Rwanda a middle-income country.

2.1 Rwanda 2020: an ambitious development plan

Vision 2020 was developed in 1999 in order to clearly plan the future of the country: in 2011, less than ten years towards the realization of the vision, it has been revised since some progress already made surpassed those identified as targets. The document highlights on one hand the constraints that the country is facing, such as its low agricultural productivity, the natural barriers to trade due to land-locked nature, its poor infrastructure system and the low level of human resources development. Despite that, the Vision 2010 seeks to transform Rwanda in a middle-income country meaning achieving per capita income of 1240 US dollars, 20% poverty rate and and average life expectance of 66 years in 2020. The main tool in order to reach the goals are identified in macroeconomic stabilization and private sector development, in order to reduce aid dependency and structural economic transformation with the switch to a knowledge-based economy. The vision is therefore built on six pillars such as:

- Good governance and a capable state
- Human resources development and a knowledge based economy
- A private sector-led economy
- Infrastructure development
- Productive and market-oriented agriculture
- Regional and international economic integration

and four cross-cutting areas namely:

- Gender equality
- Protection of environment and sustainable natural resources management
- Science and technology

2.1.1 Good Governance and Capable State

Rwanda is aimed to develop as a united state characterized by the rule of law and able to support and protect its citizens without discrimination. The priority is a capacity building, in

order to allow the development of a skilled and efficient public sector, able to transform the needs of the emerging private sector in policies and strategies. In particular the field in which the implementation has to be focused are the citizens' satisfaction in services delivery and the participation at grassroots level able involve local communities in the decision making process.

2.1.2 Human resource development: transition to knowledge based economy

One of the greatest achievement and goal of the Vision 2020 deals with the development of human resources, both in terms of increasing the general health and welfare of the population both building and efficient and leading workforce.

2.1.2.1 Education

One of the most ambitious parts of this goal deals with education: Rwanda is aimed to reach "Universal Education for All", moving from a nine years basic education program to a twelve years one. In particular major emphasis will be placed on the training in the fields of technology, engineering and management to encourage the skills-development needed to make flourish the secondary and tertiary sector. The crucial element therefore will be the creation of a link between education policies and labor policies, in order to create a skilled workforce.

2.1.2.2 Health and population

The most important challenge that the country has to deal with is the high demographic pressure: Rwanda projects to reduce the fertility rate between 2011 and 2010 from 4.6 to 3 children with a subsequent decrease in population growth from 3% to 2.2%. The country has already achieved impressive improvements in education, with a drop in HIV infection from 13% in 2000 to 3% in 2011 and consistent reduction in the incidence of endemic diseases such as malaria and tuberculosis. The challenges remain with malnutrition and non-communicable disease, that will be addressed filling the shortage of specialized health personnel, improving the quality of healthcare and increasing the geographical and financial accessibility to healthcare system.

2.1.3 Private sector

One of the most interesting points of the Vision 2020 is the importance given to a leading private sector, that has to become the principle growth driver for the country and ensure the emergence of a middle class of entrepreneurs. The main tools used to foster the growth of private sector are identified in the development of infrastructures, legal framework and financial sector. A special attention is given to the labor market: the goal for 2020 is to create 1.6 million of off-farm jobs.

2.1.4 Infrastructure Development

In order to achieve a lower cost of doing business in the country the development of infrastructure is identified as one of the main driver of domestic and foreign investments. The Vision 2020 is therefore addressing the following topics: land use management, urban development, transport, communication and ICT, energy, water and waste management.

2.1.4.1 Land use management

Rwanda is characterized by acute shortage of land: therefore the necessary tool in order to foster development is a land use plan. Currently the country is still facing the ineffective management of land: development land use plan are not translated in strategic district development plan. The objectives for 2020 are an increased security on land ownership and further equipment of rural settlements with basic infrastructures and services in order to foster the development of non-agricultural income generating activities.

2.1.4.2 Urban Development

Rwandan population is still mainly rural: one of the challenges of Vision 2020 is the decongestion of agricultural zones. The goal is to reach 35% of urban population, starting from 14.8% of 2010 and decrease the income gap between those living in rural areas and those living in cities.

2.1.4.3 Transport

The main difficult of doing business in Rwanda is linked with the specific land-locked nature of the country and the consequent high transport costs to the ocean ports of Kenya and Tanzania.

The priority is therefore the creation of an alternative transport to the sea with a lower cost, identified in the regional rail extension to Tanzania and the extension to Ugandan Railway system. Furthermore a second airport capable of serving the Great Lakes region will be developed and the already reliable and safe transport network of feeder roads will be improved.

2.1.4.4 Communications and ICT

The country made rapid improvements in information and communications technology: almost the 100% of the country is covered with fibre optic and telephone network. The aim of Vision 2020 is to have internet access at all administrative level, for all secondary schools and for a large share of primary ones. The telephone services will be widespread also in rural areas, increasing the application of e-government principles. The goal is to reach 50% of internet users compared to the 4.3% in 2010.

2.1.4.5 Energy

The inadequate and expensive energy supply is a consistent barrier to development in Rwanda. The main source of energy is wood for 86.3% of the population, compared to the 99% of 2000, values responsible for massive deforestation and soil destruction. The other source of energy is imported petroleum, that accounts for more than 17% of foreign exchange. The Rwanda of Vision 2020 is aimed to become more independent in energy production and diversify into alternative energy resources, with wood accounting for 50% of national energy consumption. The main potential to be exploited is hydroelectric energy and the large deposits of methane gas located in Lake Kivu. The other goal is linked with electricity access, that was 11% in 2010 and according to the Vision will be 70% in 2020.

2.1.4.6 Water

Water is one of the main resources of the country, that is rarely facing water shortages due to the abundant rainfalls and to the presence of lakes and watercourses. Rwanda will therefore continue to invest in protection and efficient management of the water resources and infrastructures in order to achieve 100% of the population with access to clean water, compared to the 74.2% of today.

2.1.4.7 Waste Magagement

Many of the diseases affecting Rwandan population, especially the rural one, can be attributed to the consumption of contaminated water, due to the disorganized development of towns, often built without a suitable drainage system. The stagnation of sewerage, also considering the fact that most houses are built on the summit and on slopes of hills, can lead to stagnation, contamination and ideal breeding for diseases, exacerbating sanitary problems. The goal for 2020 is therefore the diffusion of sufficient and efficient sewerage and disposal system both in rural both in urban areas.

2.1.5 Productive Value and Market Oriented Agriculture

Agriculture has always been the main sector of the country since independence and has always been targeted as the main engine of economic growth. In the Vision 2020 the implementation and innovation of agricultural system in the country is set as a goal: Rwanda needs a switch from subsistence farming to a fully, commercialized agricultural sector through aggressive transformational policies.

2.1.6 Regional and Interregional Integration

One of the crucial elements of the Vision 2020 is regional economic integration, fostered by a liberal trade regime able to minimize barriers and foster direct investment. In vision 2020, the best way indicated to boost productivity is the promotion of Rwanda as a logistics, telecommunications and financial hub, taking advantage of its geographical position. Rwandan strategic position, in the middle of the Great Lakes/Eastern Africa Region, could be exploited in terms of warehouse functions and export processing zone.

2.1.7 Gender Equality

Gender equality is one of the cross-cutting issues of the Vision 2020 and one of the field in which the country has made the most astonishing progresses. On one hand the number of girls in primary and secondary education has surpassed boys with a ratio of 1.03, on the other in 2012 women represented 56% of parliamentarians. In order to continue supporting and increasing gender equality the government's policies will focus on laws on gender in order to provide

education for all and practice positive discrimination towards women with a focus on tertiary level and employment opportunities.

2.1.8 Natural resources, environment and climate change

The natural resources and climate change management is the second point of the cross-cutting issues of the Vision. Climate change has been identified has one of the main challenges that the African continent will have to face in the next years and especially Rwanda will have to deal with flooding and droughts adversely affecting agricultural production. The other treats related to climate change will be the reduction of bio-diversity and the pollution of waterways. In order to face these issues the country, according to Vision 2020, will implement policies aimed to mitigate the impact of climate change, fostering green growth.

2.1.9 Science, Technology and ICT

As stressed in the first part of this chapter, the main idea highlighted by Vision 2020 is the transformation of Rwanda in a knowledge-based economy. In order to reach the goal, science, technologies and communications, indicated as the third point of the cross-cutting issues, have a fundamental importance. Rwandan government will be highly focused on laying the foundations for ICT as a tool for self employment, innovation and job creation, with policies aimed to encourage the development of smart applications that meet economic needs and improve services delivery in both public both private both public sector.

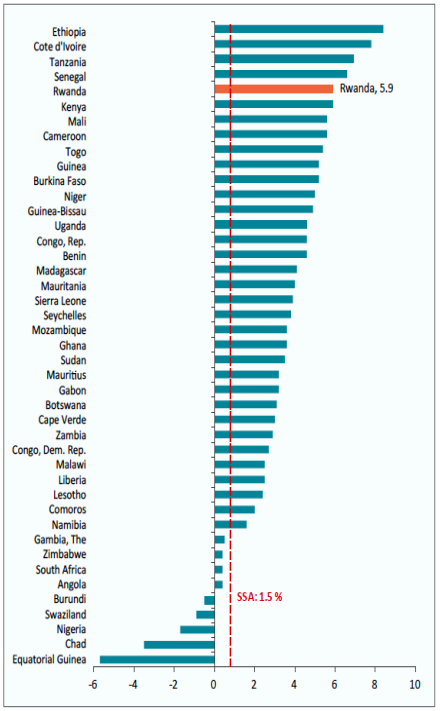
Chapter 3

The Rwandan miracle: 20 years after Rwanda 2020

Twenty years after the first version of the Vision 2020, Rwanda has become one of the most interesting and studied cases by development economists, often referred as the *Rwandan miracle*. The country has achieved impressive results both from the economic point of view, both considering the living conditions of its citizens. This chapter will give a better understanding of the progresses of the country in two of the most outstanding fields: economics and health.

3.1 Macroeconomic Developments and Productivity Patterns

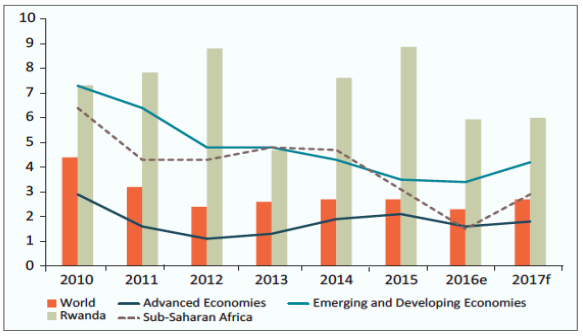
Rwanda is representing an outstanding example of a long-term sustained growth and poverty reduction. From 2000 the growth has averaged 8% and the GDP per capita growth has been 5,6%. The country has narrowed the gap with lower-middle income countries, and has improved its ranking from the seventh to the 20th poorest country in the world in 2015. The other countries able to improve their relative income ranking in Sub-Saharan Africa, namely Equatorial Guinea, Chad, Sudan and Ghana were supported by oil or gas discoveries.
In 2016, when the global economic activity decelerated to an estimated value of 2,3% growth, the worst outcome since the financial global crisis, the growth decelerated from 3,1% to 1,3% in Sub-Saharan Africa. Despite that, Rwanda's economy was among the highest growing of the area. The country has experienced two decades of economic growth: in particular, the economic expansion between 2002 and 2016, with an annual average rate of 7,8% is above the average of



Source: World Bank's Global Economic Prospects (January 2017)

FIGURE 3.1: Year on year growth for Sub-Saharan countries

all Sub-Saharan African countries.

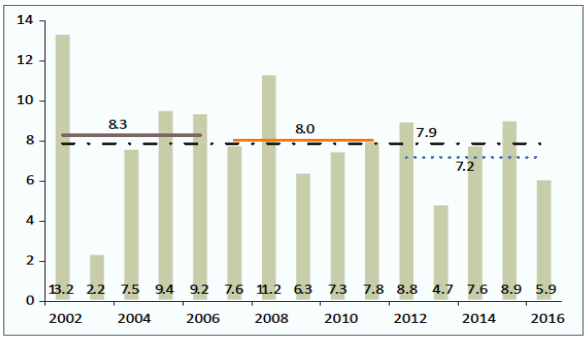


Source: NISR, World Bank's Global Economic Prospects (January 2017)

FIGURE 3.2: Rwandan growth rate and global and regional growth rates

Recently the growth rate has been decelerating: a typical phenomenon of growth-moderation in the low-income countries that, as Rwanda, have experienced a strong "catch-up" growth. The slow down has also been influenced by other factors, such as the crisis and decrease in prices of its traditional exports, namely tea, coffee and minerals. Despite the huge economic restructuring, the country is still relying on external flows as a key factors of its growth model: this is the main vulnerability of Rwanda.

On the other hand the main pillars of Rwandan growth model have been the large public



Source: NISR, World Bank staff calculations

FIGURE 3.3: Rwanda's medium and long term economic growth

investment and the strengthened institutional capacity to improve service delivery.

According to the World Bank estimates, the huge infrastructure spending, fueled by international development aids, and the strong domestic demand leaded by a shift of labour from subsistence agriculture to the service sector have been the main growth drivers for Rwanda. The consequence of the high spending in public investment has been a consistent improvement in Rwandan infrastructures and service delivery that leaded to an increment in the global logistic index. On the other side, the economy has also developed a dependence on public investments, that has been on of the causes of the slowdown in 2016. The area also experienced a substantial progress with respect to the reduction of corruption and the improvement of government efficiency. These factors have lead to an increase in the country's ranking in the world index of Doing Business, where the Rwanda is 54th , having implemented reforms in all the Doing Business indicators since 2006.

Indicators	Rwanda			EAC regional average
	2017 rank	2016 rank	Change in rank	
Starting a Business	56	59	3	102
Dealing with Construction Permits	158	109	-49	153
Getting Electricity	117	119	2	131
Registering Property	4	12	8	93
Getting Credit	2	2	no change	59
Protecting Minority Investors	102	97	-5	115
Paying Taxes	59	48	-11	107
Trading Across Borders	87	131	44	134
Enforcing Contracts	95	117	22	91
Resolving Insolvency	73	69	-4	103
Overall	**56**	**59**	**3**	**110**

Source: Doing Business Report, World Bank staff calculation

FIGURE 3.4: Rwanda's ranking on indicators of Doing Business

The World Bank estimates, therefore, consider the growth slowdown of 2016 and 2017 as a

temporary phenomenon, caused mainly by drought that affected agricultural sector, weak export prices and fiscal restraint aimed to address growing external imbalances and foresees a return to higher growth trajectory in 2018.

3.2 Health care Sector

One of the most impressive progresses of Rwanda is the one that concerns the health care sector. In the country, since the end of the genocide, the rate of child mortality, maternal mortality, and deaths from tuberculosis, AIDS, and malaria have been significantly cut. In particular, considering the time frame 2008-2015, Rwanda has been able to reduce its newborn mortality of 30%, reaching 19 deaths per 1000 births.

The main idea behind the transformation of Rwanda's health system is the accessibility of health for all the citizens. When the Rwandan constitution of 2003 formalized the inalienable right to health, a process of rebuilding a health system oriented towards ready access and accountability started. A plan of community-based health insurance has been implemented: in each of Rwanda's villages there are three community health workers, elected by the village citizens and then trained and equipped in order to deliver preventive, diagnostic and therapeutic intervention to patients. The accessibility to health has also been improved leveraging cell phones and new information technology platforms. A bright example is the partnership between the Ministry of Health and the robotic Silicon Valley company Zipline, that provides the transfer of blood and vital medicines via drones, cutting the delivery time for the remote parts of the country from four hours to half an hour. The use of drones for blood transfer is helping to reduce maternal deaths (a quarter of which are the result of blood loss during childbirth) and reduce the high incidences of malaria-induced anaemia.

The country has also worked on the fast channeling through national system of the foreign assistance: between 2000 and 2011, an increase of 1$ in foreign development aid was translated in 1,29$ in additional government spending on health in the same year.

The results of Rwandan approach to restructuring health system have been impressive: today more than 97% of infants are vaccinated against ten different diseases namely diphtheria, tetanus, pertussis, hepatitis B, haemophilus influenzae B, polio, measles, rubella, pneumococcus and rotavirus. Moreover adolescent girls are also vaccinated against papillomavirus. Births are attended by trained medical personnel and health facilities in the 69% of the cases and health workers are trained in order to prevent mother-to-child HIV transmission.

Rates of mortality under five, maternal mortality, and deaths due to tuberculosis have consistently fallen after the nineties, converging with world averages and putting Rwanda on track for the achievement of all the health-related Millennium Development Goals.

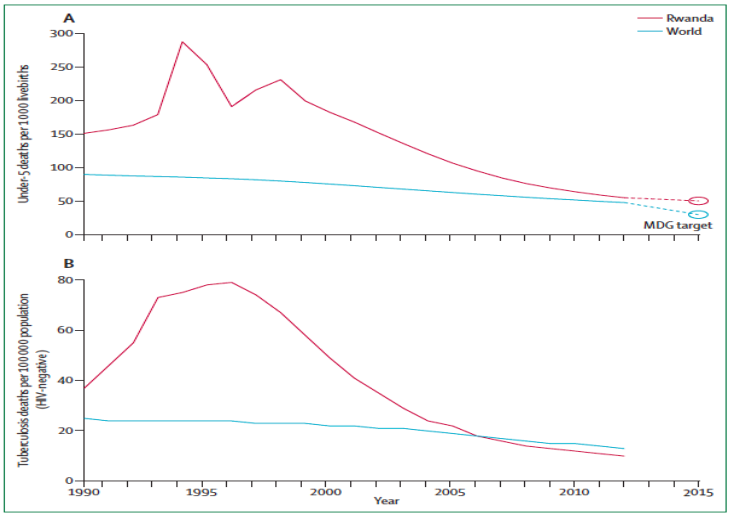


FIGURE 3.5: Child mortality and tubercolosis mortality

The decrease in children mortality has also lead to a higher family planning effect: smaller families will have more resources to spend on health and education of each child. Between 2005 and 2010 the fertility rate in the country has dropped by 25% and more than the 45% of women are now using modern contraception.

Another bright example of the efficiency of the health sector in the country is the Butaro District Hospital, located in Rwanda's Northern Province, where the first cancer treatment center in rural Africa has opened and has treated more than a thousand patients, both from Rwanda both from the neighbouring countries.

Chapter 4

Analysis

As showed in the previous chapter, after the dramatic events of the Rwandan genocide, the country, with the implementation of the Vision 2020 has been able to become one of the most promising economies of the Sub-Saharan Africa.
The aim of this chapter is to perform an econometric analysis able to understand the impact of the different pillars of the Vision 2020 on the economic growth, considering as endogenous variable the gross domestic product of the country.
The analysis will firstly build different clusters able to represent some of the pillars of the vision 2020, and then analyze how the exogenous variables of the different clusters are impacting the economic growth of the country, in the long run and in the short run.
In the end, a post event analysis will be performed on the years 2011,2012,2013 and 2014, to assess the predictive power of the models.
The analysis has been performed on Eviews 9 and on excel using data coming from the World Bank datasets, covering from 1960 to 2017. The most relevant problem faced during the choice of data has been the presence of gaps in several datasets or the complete lack of some others: for these reasons not all the pillars of the Vision 2020 have been considered as clusters of exogenous variables in the model.

4.1 Descriptive Analysis

The data chosen in order to perform the econometric analysis of the impact of the implementation policies are taken from the World Bank databank. The datasets are annual and cover at most

the period 1960-2017. The variables considered are the following:

- *gdp*
- *population_density*
- *urban_population*
- *rural_population*
- *largest_city_population*
- *mortality_rate_f*
- *mortality_rate_m*
- *mortality_rate_under5*
- *mortality_rate_infant*
- *mortality_rate_neonatal*
- *life_expectancy*
- *life_expectancy_m*
- *life_expectancy_f*
- *survival65_m*
- *survival65_f*
- *fertility_rate*
- *adolescent_fertility_rate*
- *co2_emissions*
- *inflation*
- *exports*
- *imports*
- *gross_capita_formation*
- *merchandise_trade*

- *net_aid*
- *human_capital*
- *agricultural_land*
- *cereal_production*
- *cereal_yield*
- *food_production_index*

4.1.1 Endogenous Variable: GDP

The chosen dependent variable is the gross domestic product of the country, defined as GDP. The GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. The calculation does not make deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. The data are in current US dollars. [source: World Bank]

The all time low of the GDP values is in the early sixties, probably due to the lack of records of the agricultural sector production, given the prevalence of subsistence farming. It is possible to notice two drops, the first, in 1991, given by the coffee prices crisis and the second one in 1994 due to the genocide and civil war. Starting from the end of the nineties the graph shows the impressive growth of gross domestic product highlighted in the previous chapter.

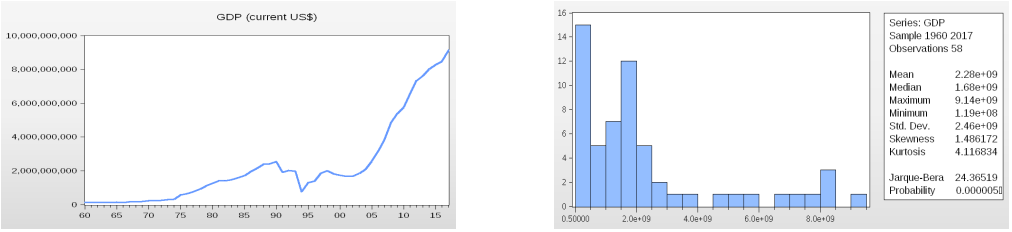


FIGURE 4.1: GDP trend and distribution

The variable is not normally distributed since it displays a high value for the Jarque-Bera normality test. The logarithmic transformation of the variable, namely *log_gdp* expressing therefore the GDP rate of change over time, is better distributed, but is still displaying a low level of curtosis.

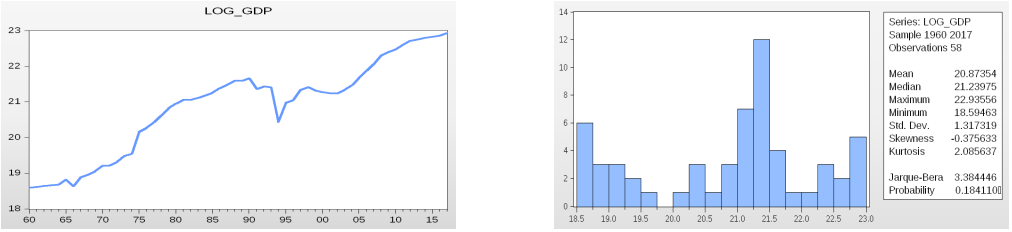


FIGURE 4.2: Logarithmic Transformation of GDP of Human Capital trend and distribution

4.1.2 Exogenous Variables

In order to highlight the some of the pillars and objectives of the Vision 2020 the exogenous variables have been divided in several clusters namely demographics, women's condition, education, health, agriculture and economics.

4.1.2.1 Demographics

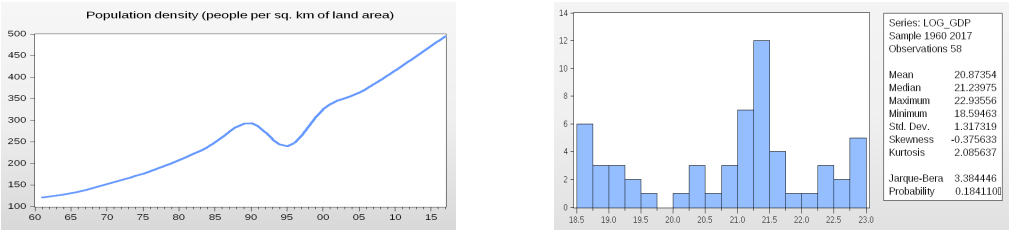


FIGURE 4.3: Population Density trend and distribution

Population Density The variable population_density displays midyear population divided by land area in square kilometers. Population counts all residents regardless of legal status or citizenship, except for refugees not permanently settled in the country of asylum. Land area is a country's total area, excluding area under major lakes and rivers, the one under national claims to continental shelf, and exclusive economic zones. Population estimates are based on national population census. The sources of data are Food and Agriculture Organization and World Bank population estimates. [source: World Bank]

The figure displays the increasing population density, related to the demographic pressure already mentioned in the previous chapters, and the drop corresponding to the years of civil war and genocide killings. The variable is normally distributed, but presents a low level of kurtosis.

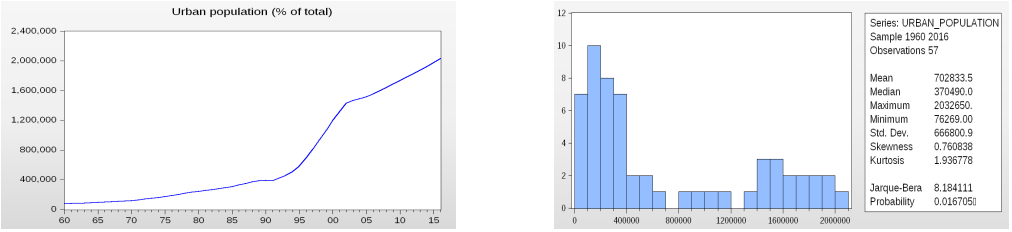


FIGURE 4.4: Urban Population trend and distribution

Urban Population The variable urban_population expresses the number of people living in urban areas as defined by national statistical offices. It is calculated using World Bank population estimates and urban ratios from the United Nations World Urbanization Prospects. [source: World Bank]

The graph of the variable depicts a consistent increase in urban population starting from the nineties. The variable is not normally distributed. The logarithmic transformation of the urban population, representing the increase rate in the Rwandese population living in urban areas, still displays low levels of skewness and kurtosis.

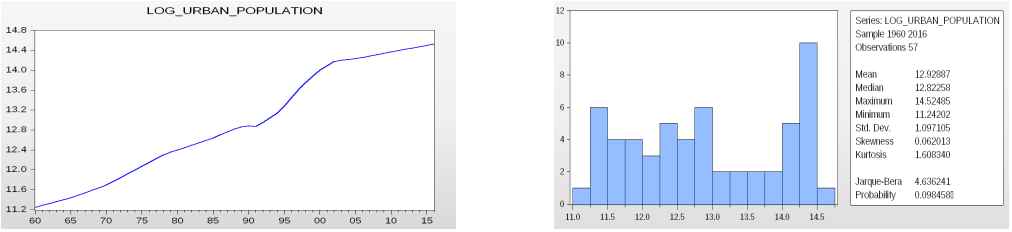


FIGURE 4.5: Logarithmic transformation of urban Population trend and distribution

Rural Population The variable rural_population expresses the number of people living in rural areas as defined by national statistical offices. It is calculated as the difference between total population and urban population. [source: World Bank]

It is clear from the graph that the growth trend in rural population has been affected by the genocide killings in the early nineties. The variable is normally distributed, despite a low level of kurtosis.

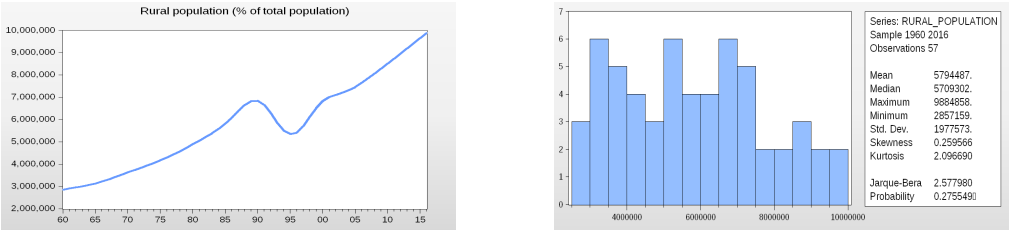


FIGURE 4.6: Rural Population trend and distribution

Population living in the largest city The variable population_largest_city is a measure of the number of people living in the largest metropolitan city of the country, in this case the capital Kigali. [source: World Bank]

The variable displays an increasing trend, not slowed by the civil war years. The variable is not normally distributed. Its logarithmic transformation, representing the rate of change in the population of Kigali, is normally distributed according to the Jarque-Bera test but is still displaying a low value of kurtosis.

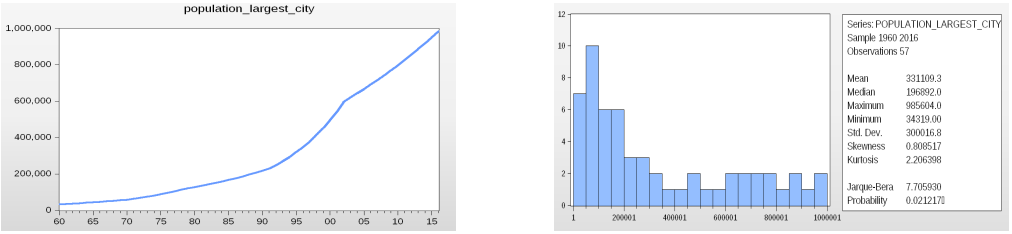


FIGURE 4.7: Population in the largest city trend and distribution

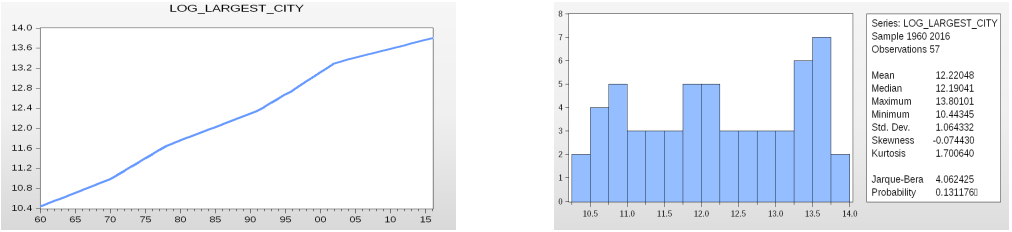


FIGURE 4.8: Logarithmic transformation of population in the largest city trend and distribution

4.1.2.2 Women's condition

In order to assess the condition of women in the country, that, as highlighted in the previous chapter is now the fifth in the global gender equality ranking, the analysis has focused on the variables fertility_rate and adolescent_fertility rate. The choice of the variables is led by the lack of other measures such as female school enrollment and female employment for the considered time frame.

The first variable is aimed to represent the possibility of reproductive choice for women and their role in the society, while the second one is aimed to give a glimpse about women's education and school enrollment.

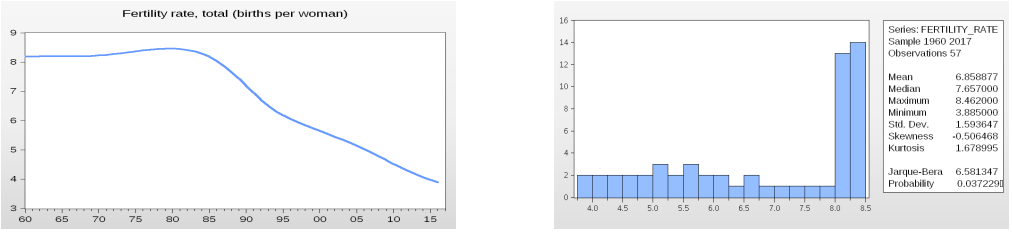


FIGURE 4.9: Fertility Rate trend and distribution

Fertility Rate The total fertility rate represents the number of children that would be born to a woman if she were to live to the end of her childbearing years and bear children in accordance with age-specific fertility rates of the specified year. Total fertility rates are based on data on registered live births from vital registration systems or, in the absence of such systems, from censuses or sample surveys. [source: World Bank]

The variable's trend displays a consistent decrease over time, starting from the mid eighties. Both the fertility_rate both its logarithmic transformation are not normally distributed.

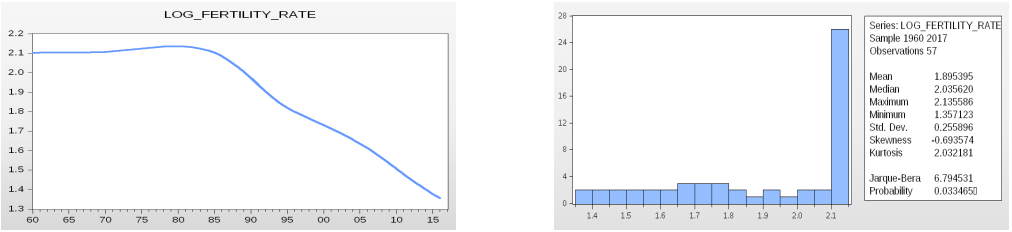


FIGURE 4.10: Logarithmic Transformation of Fertility Rate trend and distribution

Adolescent Fertility Rate The adolescent fertility rate consists in the number of births per 1000 women ages 15-19. The adolescent fertility rate represents an indicator of reproductive health as the state of physical and mental well-being in relation to the reproductive system and its functions and processes. Means of achieving reproductive health include education and services during pregnancy and childbirth, safe and effective contraception, and prevention and treatment of sexually transmitted diseases. [source: World Bank]

The variable follows the same trend as the fertility rate, with a decrease starting form the mid eighties.

Neither the variable nor its logarithmic transformation are normally distributed.

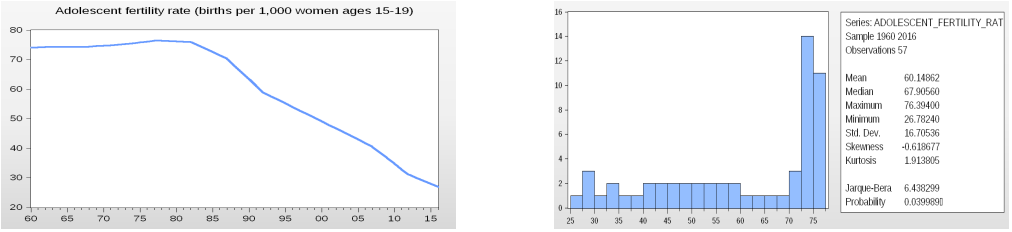


FIGURE 4.11: Adolescent Fertility Rate trend and distribution

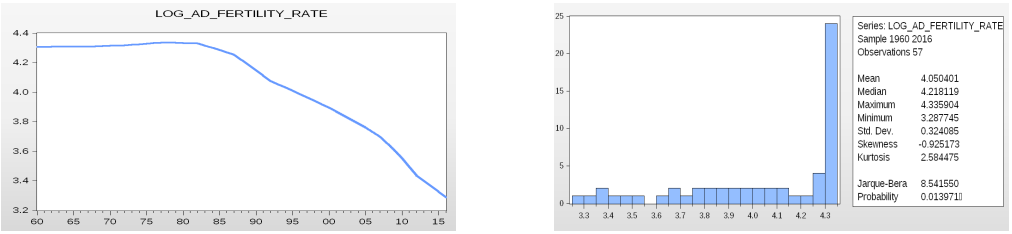


FIGURE 4.12: Logarithmic Transformation of Adolescent Fertility Rate trend and distribution

4.1.2.3 Education

As in the previous cluster, the choice of the human capital index as the representation of the education system and school enrollment in the country is mainly due to the lack of other datasets for the considered period.

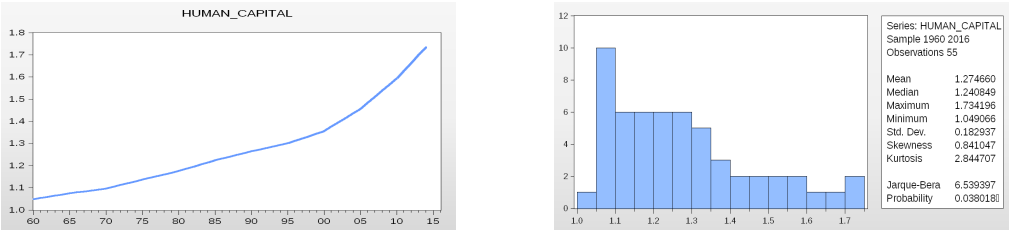


FIGURE 4.13: Human Capital trend and distribution

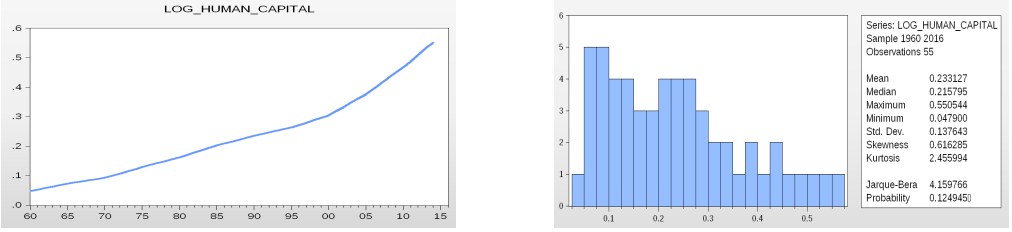


FIGURE 4.14: Logarithmic Transformation of the Index of Human Capital trend and distribution

Index of Human Capital The variable human_capital provides an index of human capital per person, which is related the average years of schooling and the return to education. [source: Federal Reserve Bank of St. Louis]

The index displays a growth trend, with an increasing slope in the mid nineties. The variable is

not normally distributed, but its logarithmic transformation, representing the increase in the index, is, despite a high value of skewness due to the presence of left tail.

4.1.3 Health

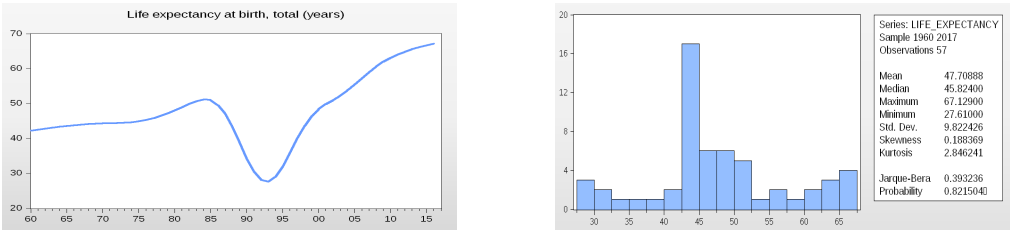


FIGURE 4.15: Life Expectancy at Birth trend and distribution

Life Expectancy at Birth The life expectancy at birth indicates the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life. The computation is based on the average number of years a newborn is expected to live if mortality patterns at the time of its birth remain constant in the future. It reflects the overall mortality level of a population, and summarizes the mortality pattern that prevails across all age groups in a given year. [source: World Bank]
Analysing the variable's trend it is clearly visible the effect of the genocide killings of 1994 and of the civil war prior to it. The variable is normally distributed.

Life Expectancy at Birth - Male The variable life_expectancy_male represents the average number of years a newborn is expected to live, if mortality patterns at the time of its birth remain constant in the future, for the male population of the country. [source: World Bank]
The trend of the variable is the same as the one of the average life expectancy, displaying a significant drop in 1994. The variable is also normally distributed.

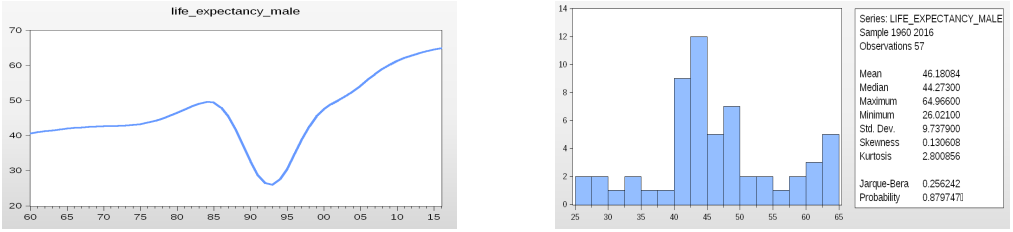


FIGURE 4.16: Male Life Expectancy at Birth trend and distribution

Life Expectancy at Birth - Female The variable life_expectancy_female represents the average number of years a newborn is expected to live, if mortality patterns at the time of its birth remain constant in the future, for the female population of the country. [source: World Bank]

Also in this variable's trend the effect of the genocide is clearly visible, but the mean value of the dataset is higher than the one of the male life expectancy. The variable is also normally distributed.

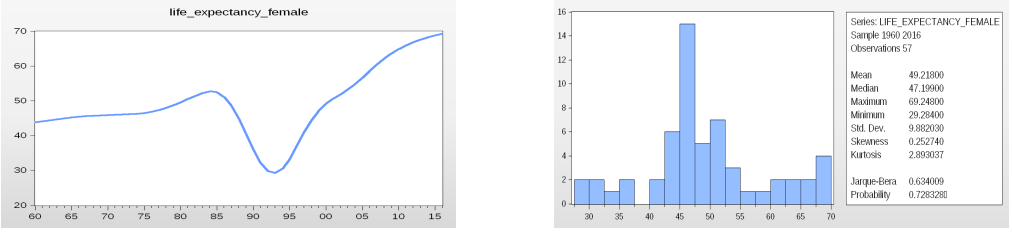


FIGURE 4.17: Female Life Expectancy at Birth trend and distribution

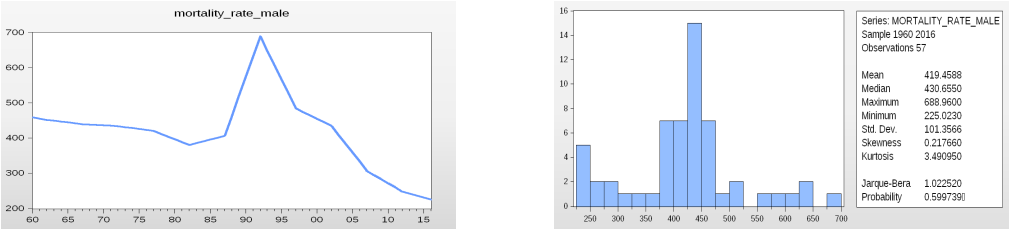


FIGURE 4.18: Male Mortality Rate Trend and Distribution

Mortality Rate - Male The variable called mortality_rate_male displays the probability of dying between the ages of 15 and 60, that is, the probability of a 15-year-old male dying before reaching age 60, if subject to age-specific mortality rates of the specified year between those ages. [source: World Bank]

The variable's graph highlights again the consequences of the violent history of the early nineties, with a peak during the genocide in 1994. After the genocide the trend is significantly decreasing. The variable is normally distributed.

Mortality Rate - Female The variable called mortality_rate_female is the measure of the probability of dying between the ages of 15 and 60 meaning the probability of a 15-year-old female dying before reaching age 60, if subject to age-specific mortality rates of the specified year between those ages. [source: World Bank]

Also this variable displays a peak in the years of genocide and an increasing trend in the prior

years of civil wars. After the genocide a decreasing trend begins.

The variable is normally distributed.

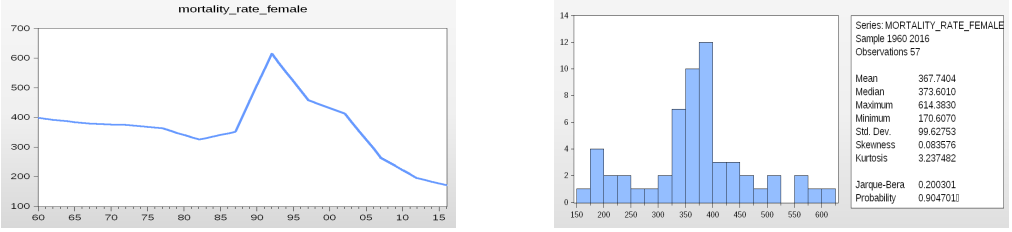


FIGURE 4.19: Female Mortality Rate Trend and Distribution

Mortality Rate - Under 5 The variable mortality_rate_under5 expresses the probability per 1000 that a newborn baby will die before reaching age five, if subject to age-specific mortality rates of the specified year. [source: World Bank]

The variable displays two peaks, one in 1994 in correspondence with the genocide and the other one in 1998. At the end of the nineties a decreasing trend starts.

The variable is normally distributed but displays a low value of skewness due to the right asymmetry.

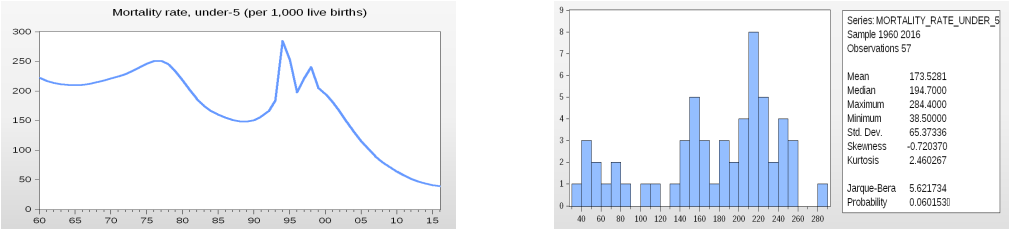


FIGURE 4.20: Mortality Rate Under 5 Trend and Distribution

Mortality Rate - Infant The variable mortality_rate_infant expresses the number of infants dying before reaching one year of age, per 1000 live births in a given year. [source: World Bank]

The variable shows the same two peaks as the mortality rate under 5, but they are less accentuated, as displayed by the mean and minimum value.

Neither the variable nor its logarithmic transformation are normally distributed, due to the low value of skewness.

Mortality Rate - Neonatal The variable mortality_rate_neonatal is the number of neonates dying before reaching 28 days of age, per 1,000 live births in a given year. [source: World Bank]

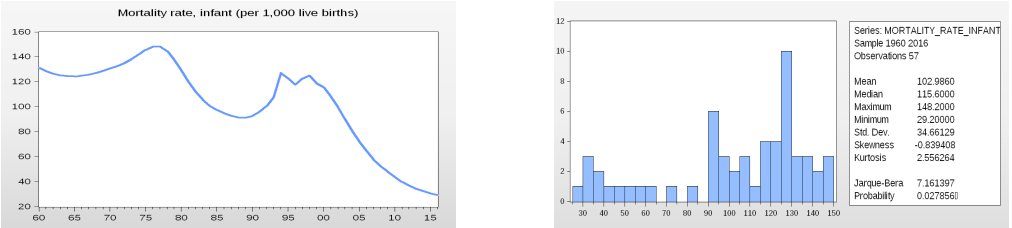


FIGURE 4.21: Infant Mortality Rate Trend and Distribution

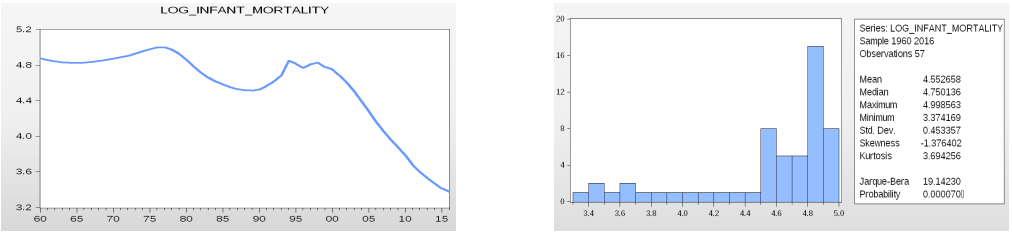


FIGURE 4.22: Logarithmic Transformation of Infant Mortality Rate Trend and Distribution

The variable displays a decreasing trend, that stopped in correspondence with the genocide years and begun again in the late nineties.

The variable is normally distributed but displays low skewness and kurtosis.

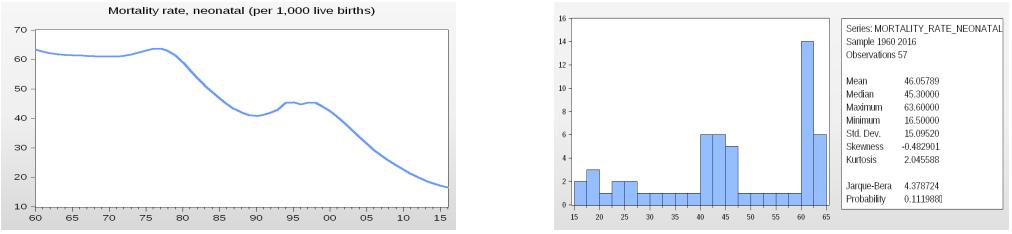


FIGURE 4.23: Neonatal Mortality Rate Trend and Distribution

Survival to Age 65 - Male The variable survival65_male refers to the percentage of a cohort of male newborn infants that would survive to age 65, if subject to age specific mortality rates of the specified year. [source: World Bank]

The variable has the same trend of the life expectancy, with a significant drop in the civil war years followed by an increasing trend.

The variable is normally distributed.

Survival to Age 65 - Female The variable survival65_female expresses the percentage of a cohort of female newborn infants that would survive to age 65, if subject to age specific mortality rates of the specified year. [source: World Bank]

The graph of the variable highlights the effect of the events of the early nineties. The mean

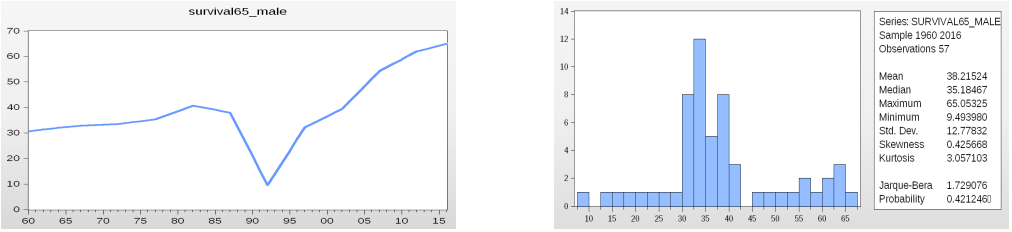


FIGURE 4.24: Survival to Age 65 - Male Trend and Distribution

value of the percentage of survival for the female population is higher than for the male one. The variable is normally distributed.

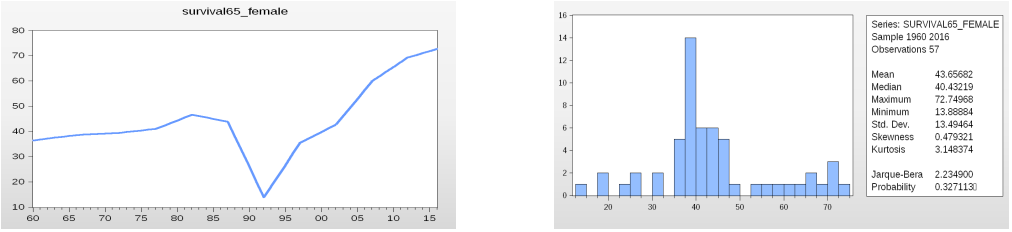


FIGURE 4.25: Survival to Age 65 - Female Trend and Distribution

4.1.4 Agriculture

The choice of an agriculture cluster is aimed to highlight one of the most challenging points of the Vision 2020, the switch from a subsistence farming to a sound commercial agricultural sector. The selected endogenous variables are therefore interpreted as indexes of an increase in agricultural productivity and efficiency.

Agricultural Land The variable agricultural_land refers to the share of land area that is arable, under permanent crops, and under permanent pastures. Arable land includes land defined by the FAO as land under temporary crops (double-cropped areas are counted once), temporary meadows for mowing or for pasture, land under market or kitchen gardens, and land temporarily fallow. Land abandoned as a result of shifting cultivation is excluded. Land under permanent crops is land cultivated with crops that occupy the land for long periods and need not be replanted after each harvest, such as cocoa, coffee, and rubber. This category includes land under flowering shrubs, fruit trees, nut trees, and vines, but excludes land under trees grown for wood or timber. Permanent pasture is land used for five or more years for forage, including natural and cultivated crops. [source: World Bank]

The graph highlights a dramatic drop in the early nineties due to the contingent coffee price

crisis and civil war. A steady increase started in the late nineties, and after a peak in 2002 the values became more stable.

Neither the variable nor its logarithmic transformation are normally distributed.

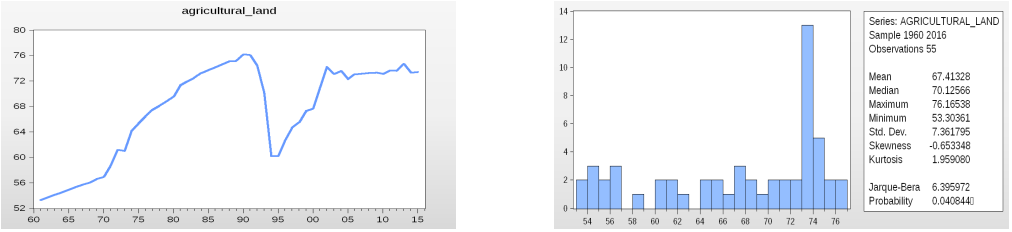


FIGURE 4.26: Agricultural Land Trend and Distribution

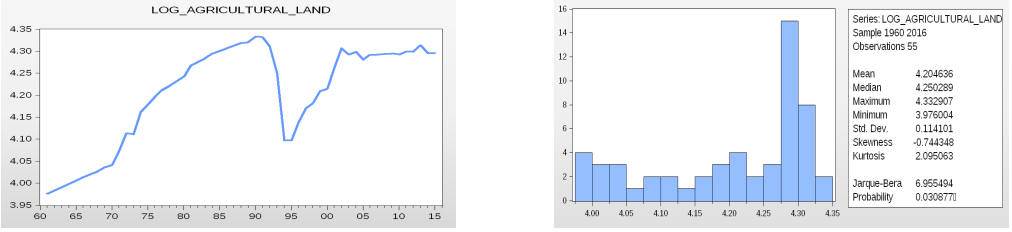


FIGURE 4.27: Logarithmic transformation of Agricultural Land Trend and Distribution

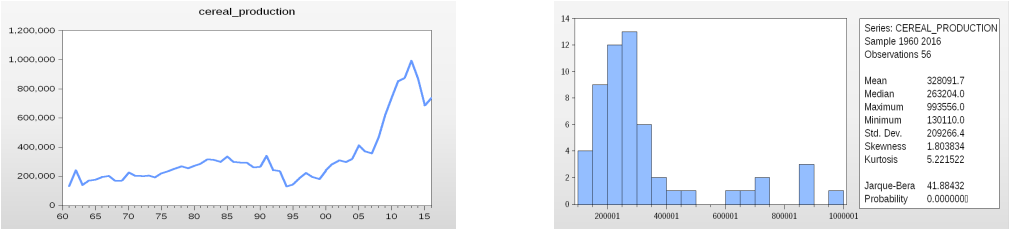


FIGURE 4.28: Cereal Production Trend and Distribution

Cereal Production The variable cereal_production relate to crops harvested for dry grain only. Cereal crops harvested for hay or harvested green for food, feed, or silage and those used for grazing are excluded. [source: World Bank]

The variable presents a weakly increasing trend interrupted in 1991 by the civil war prior to the genocide. In the late nineties the cereal production started a consistently increasing growth path, peaking in 2013.

Neither the variable nor its logarithmic transformation are normally distributed.

Cereal Yield The variable cereal_yield measured as kilograms per hectare of harvested land, includes wheat, rice, maize, barley, oats, rye, millet, sorghum, buckwheat, and mixed grains. Production data on cereals relate to crops harvested for dry grain only. [source:World Bank]

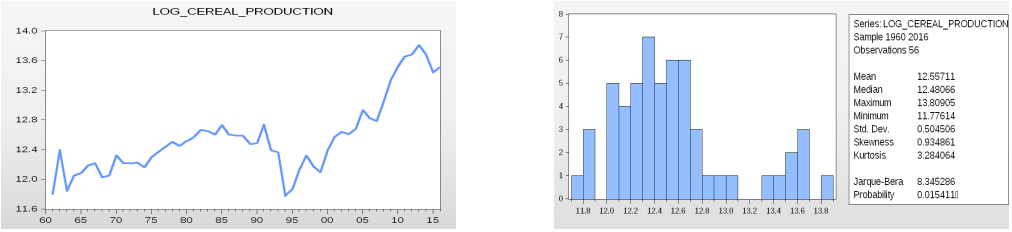


FIGURE 4.29: Logarithmic transformation of Cereal Production Trend and Distribution

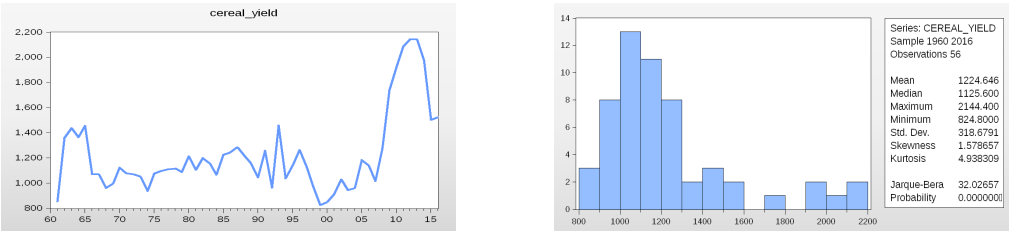


FIGURE 4.30: Cereal Yield Trend and Distribution

The variable is characterized by a very irregular path and starts increasing sharply from 2007, falling again in 2014.

Both the variable both its logarithmic transformation are not normally distributed due to the high values of skewness and kurtosis.

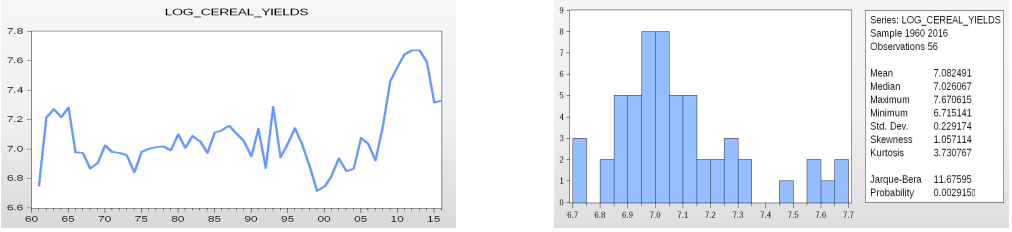


FIGURE 4.31: Logarithmic transformation of Cereal Yield Trend and Distribution

Food Production Index The agricultural production index is prepared by the Food and Agriculture Organization of the United Nations (FAO). The FAO indices of agricultural production show the relative level of the aggregate volume of agricultural production for each year in comparison with the base period 2004-2006. They are based on the sum of price-weighted quantities of different agricultural commodities produced after deductions of quantities used as seed and feed weighted in a similar manner. The resulting aggregate represents, therefore, disposable production for any use except as seed and feed. In particular the variable food_production_index is considering food crops that are considered edible and that contain nutrients. Coffee and tea are excluded because, although edible, they have no nutritive value. [source: World Bank]

The variable shows a trend of steady growth, with a significant drop in 1994, the year of the

genocide, followed by faster increase with a peak in 2013.

The variable is not normally distributed, due to the high value of skewness, but its logarithmic transformation is.

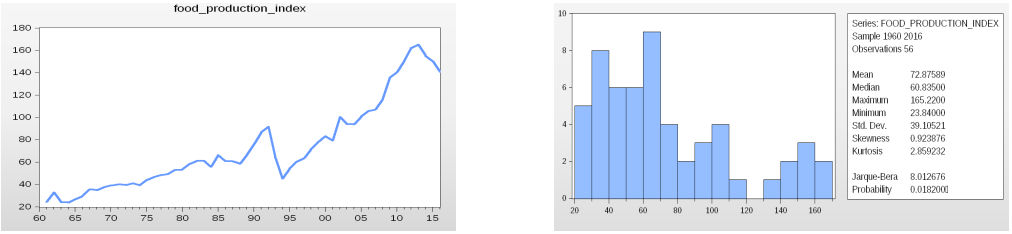


FIGURE 4.32: Food Production Index Trend and Distribution

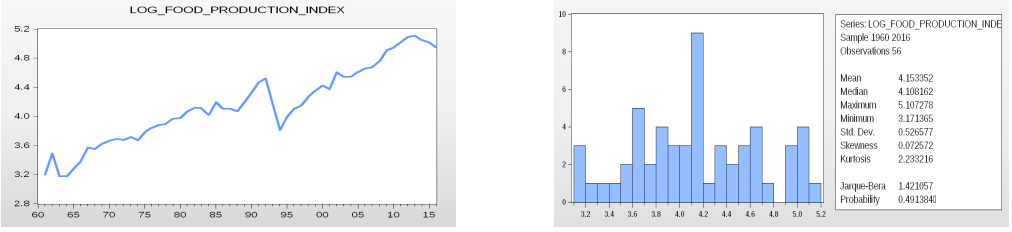


FIGURE 4.33: Logarithmic transformation of Food Production Index Trend and Distribution

4.1.5 Economics

Gross Capital Formation The variable gross_capital_formation refers to the net increase in physical assets. It expresses the outlays on additions to the fixed assets of the economy plus net changes in the level of inventories, where fixed assets include land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. [source: World Bank]

The variable displays an irregular growth path that becomes a steady increase from 2003.

The variable is normally distributed.

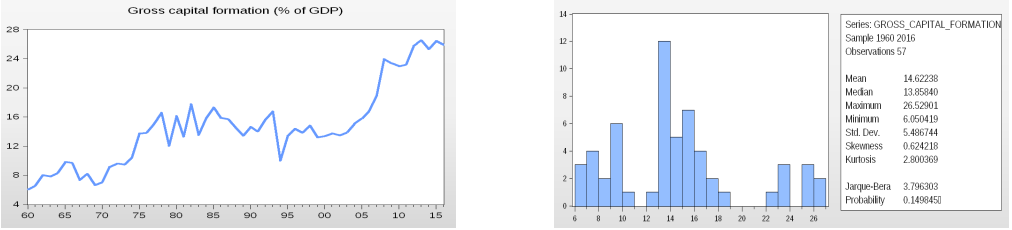


FIGURE 4.34: Gross Capital Formation Trend and Distribution

Imports The variable imports expressed as a percentage of GDP represents the value of all goods and other market services received from the rest of the world. It consists in the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services. They exclude compensation of employees and investment income (formerly called factor services) and transfer payments. [source: World Bank]

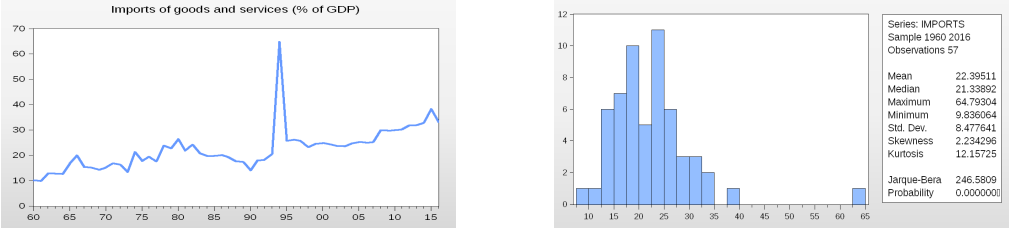


FIGURE 4.35: Imports (GDP%) Trend and Distribution

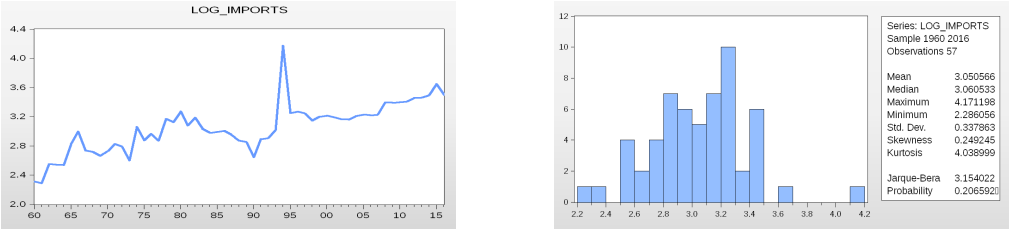


FIGURE 4.36: Logarithmic Transformation of Imports (GDP%) Trend and Distribution

The variable displays an irregular and weak growth, with an all time high in 1995, the year after the genocide.

The variable is not normally distributed, but its logarithmic transformation is, even if it still shows a high value of kurtosis.

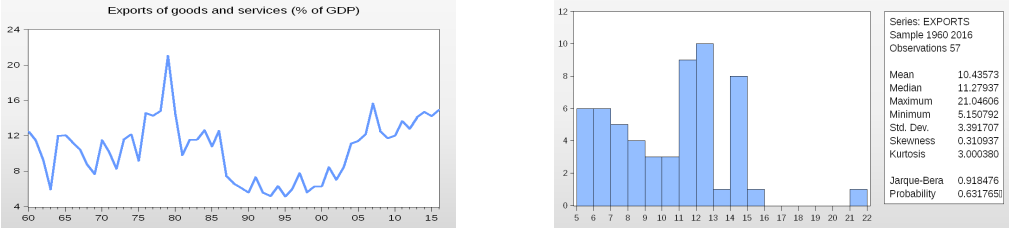


FIGURE 4.37: Exports (GDP%) Trend and Distribution

Exports The variable exports as a percentage of GDP expresses the value of all goods and other market services provided to the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services. They exclude

compensation of employees and investment income (formerly called factor services) and transfer payments. [source: World Bank]

The variable has an irregular path characterized by an all time hight at the end of the seventies, followed by a decrease that lasts until the early 2000s, when it starts increasing again.

The variable is normally distributed.

Merchandise Trade The variable merchandise_trade expressed as share of GDP, refers to the sum of merchandise exports and imports divided by the value of GDP, all in current U.S. dollars. [source:World Bank]

The variable follows an irregular path, with a peak in 1994, in correspondence with the peaking value of imports. In the early 2000s the trend becomes more regular towards a constant increase.

The variable is normally distributed.

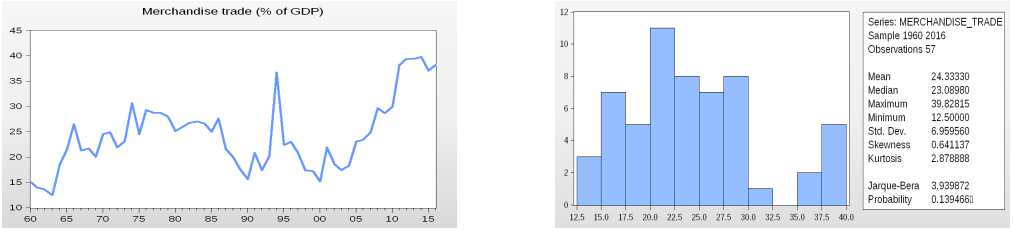


FIGURE 4.38: Merchandise Trade (GDP%) Trend and Distribution

Inflation The variable inflation expresses the annual growth rate of the GDP implicit deflator aimed to show the rate of price change in the economy as a whole. The GDP implicit deflator is the ratio of GDP in current local currency to GDP in constant local currency. [source: World Bank]

The variable follows an irregular path in which two peaks emerge: the first one in the mid seventies and another one in the years of the genocide.

The variable is not normally distributed.

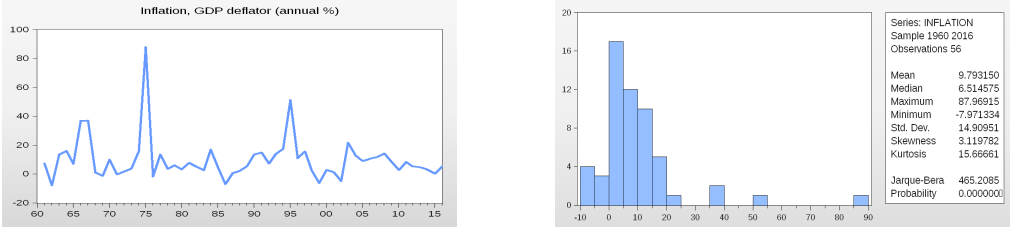


FIGURE 4.39: Inflation (GDP deflator) Trend and Distribution

Net Development Aid Th variable net_aid measures the net official development assistance and official aid received in current US dollars. Net official development assistance (ODA) consists of disbursements of loans made on concessional terms (net of repayments of principal) and grants by official agencies of the members of the Development Assistance Committee (DAC), by multilateral institutions, and by non-DAC countries to promote economic development and welfare in countries and territories in the DAC list of ODA recipients. It includes loans with a grant element of at least 25 percent (calculated at a rate of discount of 10 percent). [source: World Bank]

The variable shows an irregular but constant increase peaking in 1994 and in 2011. It is possible to notice a steady and fast growth starting from the 2000s.

The variable is not normally distributed, but its logarithmic transformation displays a better value for the Jarque-Bera test, despite the low skewness and kurtosis.

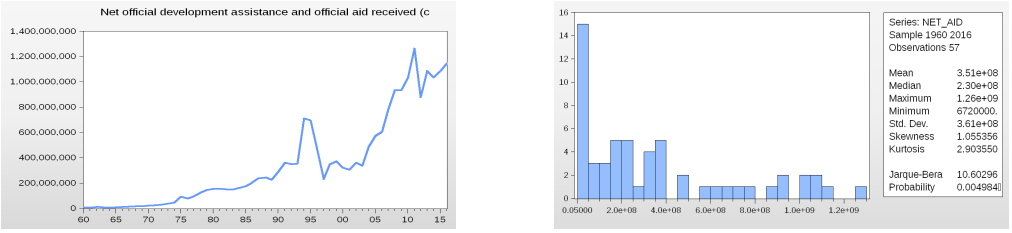


FIGURE 4.40: Net Development Aid Trend and Distribution

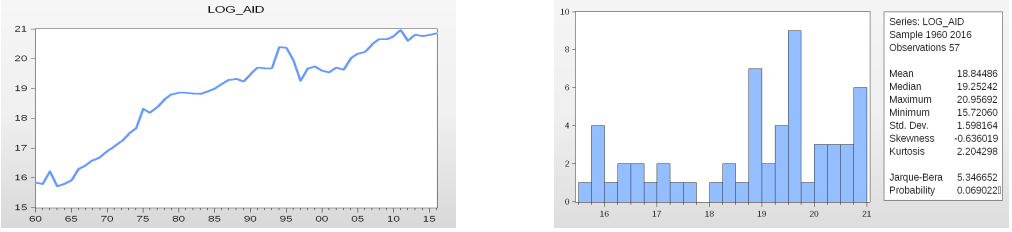


FIGURE 4.41: Logarithmic Transformation of Net Development Aid Trend and Distribution

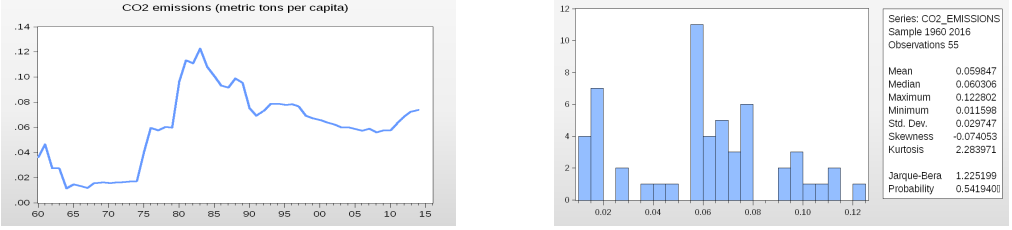


FIGURE 4.42: CO2 Emissions Trend and Distribution

CO2 Emissions The variable co2_emissions measures the carbon dioxide emissions stemming from the burning of fossil fuels and the manufacture of cement. It includes carbon dioxide

produced during consumption of solid, liquid, and gas fuels and gas flaring. [source: World Bank] The variable, given the low level of industrialization of the country, does not represent a measure of environment sustainability, but it is interpreted as measure of the increase in the industrialization process and in the development of the secondary sector.
The values of co2 emissions are increasing very fast from the mid seventies until the mid eighties, when a decreasing trend starts.The variable is normally distributed.

4.2 Integration Analysis of the Variables

The second step in the descriptive analysis of the variables is the unit root test for stationarity. The Augmented Dickey Fuller Test (ADF) aimed to identify the order of integration of the variables have been performed on all of them, leading to the results illustrated below:

Independent Variable

GDP $\sim I(2)$

LOG_GDP $\sim I(1)$

Demographics

POPULATION_DENSITY $\sim I(2)$

URBAN_POPULATION $\sim I(2)$

LOG_URBAN_POPULATION $\sim I(2)$

RURAL_POPULATION $\sim I(2)$

POPULATION_LARGEST_CITY $\sim I(2)$

LOG_POPULATION_LARGEST_CITY $\sim I(2)$

Women's Condition

FERTILITY_RATE $\sim I(2)$

LOG_FERTILITY_RATE $\sim I(2)$

ADOLESCENT_FERTILITY_RATE $\sim I(2)$

LOG_ADOLESCENT_FERTILITY_RATE $\sim I(2)$

Education

HUMAN_CAPITAL $\sim I(2)$

LOG_HUMAN_CAPITAL $\sim I(2)$

Health

LIFE_EXPECTANCY $\sim I(2)$

LIFE_EXPECTANCY_MALE $\sim I(2)$

LIFE_EXPECTANCY_FEMALE $\sim I(2)$

MORTALITY_RATE_MALE $\sim I(2)$

MORTALITY_RATE_FEMALE $\sim I(2)$

MORTALITY_RATE_UNDER5 $\sim I(1)$

MORTALITY_RATE_INFANT$\sim I(1)$

MORTALITY_RATE_NEONATAL $\sim I(1)$

SURVIVAL65_MALE $\sim I(2)$

SURVIVAL65_FEMALE $\sim I(2)$

LOG_SURVIVAL65_MALE $\sim I(1)$

LOG_SURVIVAL65_FEMALE $\sim I(1)$

Agriculture

AGRICULTURAL_LAND $\sim I(1)$

CEREAL_PRODUCTION $\sim I(1)$

LOG_CEREAL_PRODUCTION $\sim I(1)$

CEREAL_YIELD $\sim I(1)$

LOG_CEREAL_YIELD $\sim I(1)$

FOOD_PRODUCTION_INDEX $\sim I(1)$

Economics

GROSS_CAPITAL $\sim I(1)$

IMPORTS $\sim I(1)$

LOG_IMPORTS $\sim I(1)$

EXPORTS $\sim I(1)$

LOG_EXPORTS $\sim I(1)$

MERCHANDISE_TRADE $\sim I(1)$

INFLATION $\sim I(2)$

NET_AID $\sim I(1)$

LOG_NET_AID $\sim I(1)$

CO2_EMISSIONS $\sim I(1)$

The variables I(2) will be excluded from the analysis that will be performed on processes I(1). The exogenous variables considered in the model are therefore displayed below.

The model will therefore be a semi-logarithmic one, with a logarithmic endogenous variable and both logarithmic both non logarithmic exogenous variables.

The analysis will be performed on the sample that goes from 1961 to 2014, and in order to perform post-event forecasts, will be divided in two sub-samples. The first one, from 1961 to

Variable	Distribution	Order of Integration
log_gdp	normally distributed	I(1)
mortality_rate_under5	normally distributed	I(1)
mortality_rate_infant	not normally distributed	I(1)
mortality_rate_neonatal	normally distributed	I(1)
log_survival65_m	not normally distributed	I(1)
log_survival65_f	not normally distributed	I(1)
co2_emissions	normally distributed	I(1)
log_exports	normally distributed	I(1)
log_imports	normally distributed	I(1)
gross_capital_formation	normally distributed	I(1)
merchandise_trade	normally distributed	I(1)
log_aid	normally distributed	I(1)
agricultural_land	not normally distributed	I(1)
log_cereal_production	not normally distributed	I(1)
log_cereal_yield	not normally distributed	I(1)
food_production_index	not normally distributed	I(1)

FIGURE 4.43: Final selection of variables to be included in the model

2010 will be used for the specification and esimate of the model, while the second one, from 2011 to 2014, called *virtual future* will be used for forecasting purposes.

4.3 Static Equation Estimate

The first part of the model, the static equation, is estimated using OLS method and applying the correction to the variance-covariance matrix estimate of estimators by Newey-West. The procedure is called HAC Standard Errors & Covariance Estimator and is consistent in presence of heteroskedastic and autocorrelated errors as well as unknown. The sample covered by the analysis goes from 1961 to 2014.
The static general equation obtained is the following:

Proceeding with the elimination of non significant coefficients of the variables, the static final equation is obtained.

The residual series of the of the static final equation is called static_residuals. Analyzing the autocorrelation plot we can notice that there is no evidence of presence of unit root. The result is confirmed by the ADF test.
If one one hand the behavior of the residuals allows for the acceptance of the co-integration

Dependent Variable: LOG_GDP
Method: Least Squares
Date: 10/03/18 Time: 23:01
Sample (adjusted): 1961 2014
Included observations: 54 after adjustments
HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth = 4.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	9.566926	2.877458	3.324784	0.0020
MORTALITY_RATE_UNDER_5	-0.002363	0.003959	-0.596955	0.5541
MORTALITY_RATE_INFANT	0.023656	0.011596	2.039961	0.0483
MORTALITY_RATE_NEONATAL	-0.061301	0.033933	-1.806529	0.0788
LOG_SURVIVAL65_F	3.260246	2.815437	1.157990	0.2541
LOG_SURVIVAL65_M	-2.524155	2.363280	-1.068073	0.2922
CO2_EMISSIONS	6.760804	1.658971	4.075299	0.0002
LOG_EXPORTS	0.101611	0.150209	0.676460	0.5028
LOG_IMPORTS	-0.348485	0.146734	-2.374941	0.0227
GROSS_CAPITAL_FORMATION	0.037368	0.018262	2.046224	0.0477
MERCHANDISE_TRADE	-0.005923	0.009552	-0.620035	0.5389
LOG_AID	0.302990	0.124497	2.433714	0.0198
AGRICULTURAL_LAND	0.032172	0.015575	2.065695	0.0457
LOG_CEREAL_PRODUCTION	-0.128772	0.267238	-0.481864	0.6327
LOG_CEREAL_YIELD	0.369333	0.204788	1.803491	0.0792
FOOD_PRODUCTION_INDEX	0.001471	0.004041	0.364016	0.7179

R-squared	0.991091	Mean dependent var	20.80440
Adjusted R-squared	0.987575	S.D. dependent var	1.239354
S.E. of regression	0.138150	Akaike info criterion	-0.879758
Sum squared resid	0.725246	Schwarz criterion	-0.290430
Log likelihood	39.75348	Hannan-Quinn criter.	-0.652478
F-statistic	281.8301	Durbin-Watson stat	1.047303
Prob(F-statistic)	0.000000	Wald F-statistic	871.3636
Prob(Wald F-statistic)	0.000000		

FIGURE 4.44: Static general equation estimate

hypothesis and the coefficient can therefore be interpreted as long-run coefficients, on the other we should consider that all the variables of the static model are measured using different measurement scales. The modulus of the estimated coefficients is not suitable in order to evaluate the impact of a change in the independent variable on the dependent one.

The problem can be solved analyzing the standardized regression coefficients.

The variables affecting log_gdp in the long run model are seven: mortality_rate_neonatal, log survival65_f, co2_emissions, log_imports, gross_capital_formation, log_aid and agricultural_land. The impact is therefore given by two variables of the *health* group, four variables of the *economics* group and one variable of the *agriculture* group.

All the sign of the coefficients are aligned with the expectations: the increase in neonatal mortality rate has a negative effect on GDP and the same can be said about the growth of imports. An increase in the other variables which are the emissions of CO2, the growth rate of female population surviving to 65 years old, the gross capital formation, the agricultural land and the growth in international aid, has a positive impact on the GDP growth rate.

Dependent Variable: LOG_GDP
Method: Least Squares
Date: 09/26/18 Time: 23:32
Sample (adjusted): 1961 2014
Included observations: 54 after adjustments
HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth = 4.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	11.16027	0.981767	11.36754	0.0000
MORTALITY_RATE_NEONATAL	-0.013212	0.003518	-3.756139	0.0005
LOG_SURVIVAL65_F	0.168921	0.056934	2.966934	0.0048
CO2_EMISSIONS	4.755740	1.222274	3.890896	0.0003
LOG_IMPORTS	-0.418120	0.108910	-3.839140	0.0004
GROSS_CAPITAL_FORMATION	0.049070	0.008727	5.622960	0.0000
LOG_AID	0.432183	0.055797	7.745698	0.0000
AGRICULTURAL_LAND	0.026475	0.008868	2.985447	0.0045

R-squared	0.988527	Mean dependent var	20.80440
Adjusted R-squared	0.986781	S.D. dependent var	1.239354
S.E. of regression	0.142494	Akaike info criterion	-0.923083
Sum squared resid	0.934006	Schwarz criterion	-0.628418
Log likelihood	32.92323	Hannan-Quinn criter.	-0.809442
F-statistic	566.1940	Durbin-Watson stat	1.212978
Prob(F-statistic)	0.000000	Wald F-statistic	1075.663
Prob(Wald F-statistic)	0.000000		

FIGURE 4.45: Static final equation estimate

Date: 10/04/18 Time: 21:35
Sample: 1960 2016
Included observations: 54

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.375	0.375	8.0409	0.005
		2	0.084	-0.066	8.4505	0.015
		3	-0.179	-0.220	10.360	0.016
		4	-0.276	-0.155	14.972	0.005
		5	-0.339	-0.209	22.082	0.001
		6	-0.339	-0.230	29.306	0.000
		7	-0.196	-0.115	31.772	0.000
		8	-0.004	-0.046	31.773	0.000
		9	0.219	0.072	34.981	0.000
		10	0.198	-0.093	37.674	0.000
		11	0.174	-0.034	39.807	0.000
		12	0.013	-0.145	39.819	0.000
		13	-0.063	-0.087	40.109	0.000
		14	-0.039	0.054	40.223	0.000
		15	-0.239	-0.274	44.661	0.000
		16	-0.144	-0.027	46.300	0.000
		17	-0.079	-0.084	46.806	0.000
		18	0.093	-0.029	47.540	0.000
		19	0.166	0.003	49.920	0.000
		20	0.147	-0.082	51.843	0.000
		21	0.121	0.000	53.195	0.000
		22	0.072	-0.014	53.687	0.000
		23	-0.011	-0.064	53.700	0.000
		24	-0.073	0.056	54.244	0.000

Null Hypothesis: STATIC_RESIDUALS has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.853080	0.0000
Test critical values:	1% level	-2.609324	
	5% level	-1.947119	
	10% level	-1.612867	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(STATIC_RESIDUALS)
Method: Least Squares
Date: 10/04/18 Time: 21:27
Sample (adjusted): 1962 2014
Included observations: 53 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
STATIC_RESIDUALS(-1)	-0.619269	0.127603	-4.853080	0.0000

R-squared	0.310970	Mean dependent var	0.004875
Adjusted R-squared	0.310970	S.D. dependent var	0.147522
S.E. of regression	0.122455	Akaike info criterion	-1.343455
Sum squared resid	0.779754	Schwarz criterion	-1.306280
Log likelihood	36.60156	Hannan-Quinn criter.	-1.329159
Durbin-Watson stat	1.948940		

FIGURE 4.46: Correlogram and ADF test for the residuals

The variable log_aid is the higher in modulus, followed by gross_capital_formation, agricultural_land and mortality_rate_neonatal. It can therefore be said that in the long run model the amount of international development aid received is affecting more the dependent variable, log_gdp. The second variables in order of importance are gross_capital_formation, agricultural_land and mortality_rate_neonatal: an increase in the gross capital formation and in agricultural_land will

Scaled Coefficients
Date: 10/04/18 Time: 22:05
Sample: 1960 2016
Included observations: 54

Variable	Coefficient	Standardized Coefficient	Elasticity at Means
C	11.16027	NA	0.536438
MORTALITY_RATE_N...	-0.013212	-0.151611	-0.029736
LOG_SURVIVAL65_F	0.168921	0.043873	0.030108
CO2_EMISSIONS	4.755740	0.114533	0.013780
LOG_IMPORTS	-0.418120	-0.106564	-0.061196
GROSS_CAPITAL_F...	0.049070	0.199232	0.033855
LOG_AID	0.432183	0.537763	0.391105
AGRICULTURAL_LAND	0.026475	0.157732	0.085645

FIGURE 4.47: Scaled Coefficients

increase the GDP growth, an increase in the neonatal mortality rate will decrease it. The impact of the three variables in absolute value is almost the same. The third variables in order of importance are the increase in the imports and the co2 emissions, followed by the growth rate of survival to 65 years old in the female population, whose standardized coefficient is close to zero.

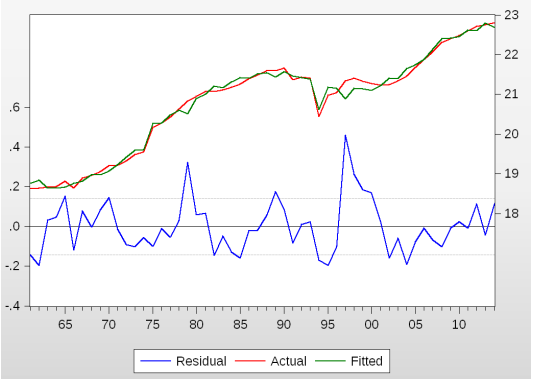


FIGURE 4.48: Long Run Curve

Finally we can plot the long run curve, where the deviation of actual values from the fitted ones is plotted by the blue curve of residuals.

We can notice that the long-run curve is only partially able to follow the trend of the fitted one, especially in the late nineties, when the country was recovering from the economic disaster caused by the genocide, and the actual value in the GDP growth was higher than the fitted one. The discrepancy between the fitted and actual value can be linked to the negative peak in the net official aid received in 1997.

Another significant gap can be noticed in the late seventies, in the first years of the Second Republic, characterized by a steady economic growth. Again in this case the actual GDP value is higher than the fitted one.

4.4 Dynamic Equation Estimation

Dependent Variable: D(LOG_GDP)
Method: Least Squares
Date: 10/05/18 Time: 23:53
Sample (adjusted): 1963 2010
Included observations: 48 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LOG_GDP(-1))	0.360570	0.248653	1.450090	0.1676
C	0.047758	0.038310	1.246605	0.2317
D(MORTALITY_RATE_UNDER5)	0.001216	0.005388	0.225712	0.8245
D(MORTALITY_RATE_UNDER5(-1))	-0.004796	0.006086	-0.788055	0.4429
D(MORTALITY_RATE_INFANT)	-0.005872	0.032167	-0.182550	0.8576
D(MORTALITY_RATE_INFANT(-1))	0.014028	0.035341	0.396930	0.6970
D(MORTALITY_RATE_NEONATAL)	-0.041767	0.171683	-0.243281	0.8111
D(MORTALITY_RATE_NEONATAL(-1))	0.056522	0.154062	0.366880	0.7188
D(LOG_SURVIVAL65_F)	-2.035777	5.067957	-0.401696	0.6936
D(LOG_SURVIVAL65_F(-1))	4.526079	4.770640	0.948736	0.3578
D(LOG_SURVIVAL65_M)	1.286624	3.824985	0.336374	0.7412
D(LOG_SURVIVAL65_M(-1))	-3.295710	3.582668	-0.919904	0.3722
D(CO2_EMISSIONS)	3.406007	2.807481	1.213190	0.2438
D(CO2_EMISSIONS(-1))	-0.008626	2.917356	-0.002957	0.9977
D(LOG_EXPORTS)	0.045384	0.127906	0.354820	0.7277
D(LOG_EXPORTS(-1))	0.042376	0.112947	0.375182	0.7128
D(LOG_IMPORTS)	-0.230233	0.261966	-0.878863	0.3933
D(LOG_IMPORTS(-1))	0.386520	0.279537	1.382712	0.1870
D(GROSS_CAPITAL_FORMATION)	0.016071	0.014219	1.130256	0.2761
D(GROSS_CAPITAL_FORMATION(-...	-0.017750	0.017126	-1.036425	0.3164
D(MERCHANDISE_TRADE)	-0.005004	0.012555	-0.398568	0.6958
D(MERCHANDISE_TRADE(-1))	-0.003302	0.012665	-0.260707	0.7979
D(LOG_AID)	0.123677	0.124509	0.993320	0.3363
D(LOG_AID(-1))	-0.146526	0.158522	-0.924323	0.3699
D(AGRICULTURAL_LAND)	0.021435	0.022984	0.932595	0.3658
D(AGRICULTURAL_LAND(-1))	-0.004428	0.017490	-0.253183	0.8036
D(LOG_CEREAL_PRODUCTION)	-0.156101	0.261886	-0.596065	0.5600
D(LOG_CEREAL_PRODUCTION(-1))	-0.071480	0.195317	-0.365970	0.7195
D(LOG_CEREAL_YIELD)	0.158911	0.271911	0.584425	0.5676
D(LOG_CEREAL_YIELD(-1))	-0.305191	0.252562	-1.208378	0.2456
D(FOOD_PRODUCTION_INDEX)	0.002236	0.005917	0.377981	0.7107
D(FOOD_PRODUCTION_INDEX(-1))	0.004997	0.004624	1.080541	0.2970
RESIDUALS_ECM(-1)	-0.793434	0.261188	-3.037792	0.0083

R-squared	0.920321	Mean dependent var	0.079847
Adjusted R-squared	0.750340	S.D. dependent var	0.211056
S.E. of regression	0.105456	Akaike info criterion	-1.449191
Sum squared resid	0.166816	Schwarz criterion	-0.162740
Log likelihood	67.78057	Hannan-Quinn criter.	-0.963039
F-statistic	5.414256	Durbin-Watson stat	2.409875
Prob(F-statistic)	0.000568		

FIGURE 4.49: General dynamic equation

Given the acceptance of the hypothesis of no unit roots in the residuals of the estimated static equation, the dynamic model can be estimated in the Error Correction Model form. Given the small sample of annual data and the need to leave a sufficient number of degrees of freedom, one period time lag has been chosen. The general dynamic equation estimate is displayed in figure 4.49. Proceeding in the elimination process of non-significant regressors the dynamic final equation is obtained, displayed in figure 4.50.

It is possible to notice that the coefficient of the ECM component, namely residuals_ecm is -0.793722, therefore between the open interval (-2, 0) confirming the necessary condition for the stability of the model.

The other relevant observation on the final dynamic equation is the fact that the variables of the health cluster that were significant in the long run model are not significant in the short run one. On the other hand two variables of the agriculture cluster, cereal_yield and food_production_index, that were neutral in the long-run model, contributes instead to the short-run dynamic. In the

Dependent Variable: D(LOG_GDP)
Method: Least Squares
Date: 10/06/18 Time: 00:02
Sample (adjusted): 1963 2010
Included observations: 48 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.034391	0.015949	2.156285	0.0378
D(LOG_GDP(-1))	0.496309	0.115453	4.298797	0.0001
D(CO2_EMISSIONS)	3.924195	1.483472	2.645278	0.0120
D(LOG_IMPORTS)	-0.236022	0.081126	-2.909327	0.0062
D(LOG_IMPORTS(-1))	0.463545	0.092726	4.999067	0.0000
D(GROSS_CAPITAL_FORMATION)	0.015968	0.007122	2.242120	0.0312
D(GROSS_CAPITAL_FORMATION(-...	-0.019750	0.008591	-2.299058	0.0274
D(LOG_AID(-1))	-0.176902	0.062202	-2.844017	0.0073
D(AGRICULTURAL_LAND)	0.031743	0.008344	3.804228	0.0005
D(LOG_CEREAL_YIELD(-1))	-0.421407	0.104628	-4.027664	0.0003
D(FOOD_PRODUCTION_INDEX(-1))	0.004224	0.001905	2.218043	0.0329
RESIDUALS_ECM(-1)	-0.793722	0.125360	-6.331525	0.0000

R-squared	0.890780	Mean dependent var	0.079847
Adjusted R-squared	0.857408	S.D. dependent var	0.211056
S.E. of regression	0.079698	Akaike info criterion	-2.008831
Sum squared resid	0.228663	Schwarz criterion	-1.541031
Log likelihood	60.21195	Hannan-Quinn criter.	-1.832049
F-statistic	26.69191	Durbin-Watson stat	2.237868
Prob(F-statistic)	0.000000		

FIGURE 4.50: Final dynamic equation

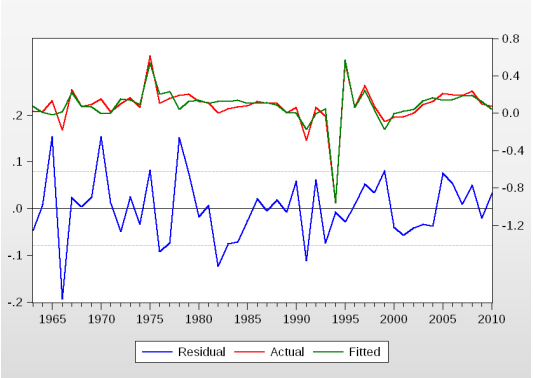


FIGURE 4.51: Short-run curve

analysis of the short-run curve, the higher peaks in the residuals are in the late sixties and in the late seventies, when the model does not seem able to grasp the oscillations caused by the change in the political scenario. In the late sixties the country was facing the effects of the *peasant revolution*, while in the late seventies the effects of the switch to the Second Republic.

4.5 Residuals Analysis

The next step in the evaluation of the dynamic model is the analysis of residuals, aimed to confirm the hypothesis that they are a realization of a white noise process. The residuals are normally distributed. Furthermore through the analysis of the correlogram of residuals and correlogram of residual squared it is possible to state the absence of autocorrelation and heteroskedasticity respectively.

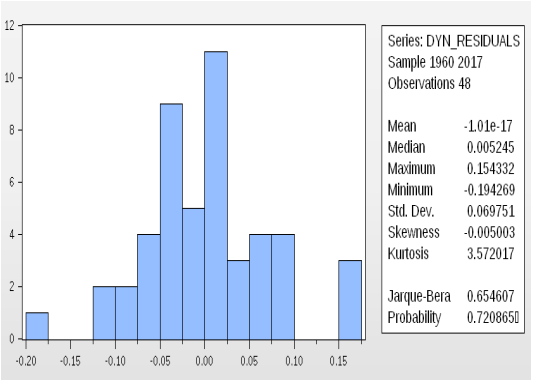


FIGURE 4.52: Residuals empirical distribution

Date: 10/06/18 Time: 11:50
Sample: 1960 2010
Included observations: 48
Q-statistic probabilities adjusted for 11 dynamic regressors

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	-0.126	-0.126	0.8104	0.368
		2	-0.015	-0.031	0.8217	0.663
		3	-0.032	-0.038	0.8758	0.831
		4	-0.291	-0.306	5.4859	0.241
		5	0.035	-0.053	5.5560	0.352
		6	-0.056	-0.090	5.7380	0.453
		7	-0.112	-0.189	6.4666	0.486
		8	0.184	0.045	8.4910	0.387
		9	0.091	0.110	8.9989	0.437
		10	0.138	0.138	10.194	0.424
		11	0.147	0.176	11.593	0.395
		12	-0.306	-0.184	17.850	0.120
		13	-0.053	-0.065	18.046	0.156
		14	-0.034	0.029	18.126	0.201
		15	-0.173	-0.130	20.293	0.161
		16	0.021	-0.184	20.325	0.206
		17	-0.007	-0.080	20.329	0.258
		18	0.075	-0.019	20.780	0.291
		19	0.128	-0.089	22.144	0.277
		20	0.065	0.043	22.501	0.314

Date: 10/06/18 Time: 11:50
Sample: 1960 2010
Included observations: 48

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.182	0.182	1.6904	0.194
		2	-0.161	-0.200	3.0384	0.219
		3	-0.165	-0.101	4.4949	0.213
		4	0.233	0.278	7.4547	0.114
		5	0.082	-0.080	7.8310	0.166
		6	-0.016	0.037	7.8456	0.250
		7	-0.070	0.015	8.1349	0.321
		8	0.082	0.034	8.5382	0.383
		9	0.016	-0.026	8.5542	0.479
		10	-0.021	-0.011	8.5817	0.572
		11	-0.058	-0.019	8.7986	0.640
		12	0.294	0.320	14.562	0.266
		13	0.206	0.072	17.469	0.179
		14	-0.041	-0.055	17.585	0.226
		15	-0.076	0.140	18.005	0.262
		16	0.073	-0.059	18.408	0.301
		17	0.079	-0.027	18.892	0.335
		18	-0.051	-0.035	19.097	0.386
		19	-0.090	-0.066	19.770	0.409
		20	-0.090	-0.124	20.464	0.429

FIGURE 4.53: Correlogram of Residuals and Correlogram of Residuals Squared

4.6 Impulse Response Functions

In order to analyze the trends of the impulse response functions, ADL form coefficients were computed.

We consider the the ADL(p,q) model $\alpha(L)y_t = \beta(L)x_t + \epsilon_t$ where we have:

$\alpha(L) = (1 - \alpha_1 L - \alpha_2 L^2 - ... - \alpha_p L^p)$

$\beta(L) = (1 - \beta_1 L - \beta_2 L^2 - ... - \beta_p L^p)$

$\epsilon_t \sim WN(0, \sigma^2)$

x_t a strict exogenous process that is: $E(x_t, \epsilon_s) = 0, \forall t, s$

If the system described by the equation is in its *steady state* it has reached a stable condition that does not change over time. The state of stillness implies the absence of the error term leading to the steady state model: $\alpha(1)y = \beta(1)x$ and since the operator L when operates on constant becomes 1 we can rewrite: $y = \frac{\beta(1)}{\alpha(1)}x = \frac{\sum_{i=0}^{q}\beta(i)}{1-\sum_{i=1}^{p}\alpha(i)}$.
The ratio $\frac{\beta(1)}{\alpha(1)}$ is the so called *long run coefficient* representing the increment of the output in the long-run when the system is shocked by an unit impulse in the steady-state exogenous variable. Under the stability condition hypothesis of the model we can write:

$$y_t = \alpha(L)^{-1}\beta(L)x_t + \alpha(L)^{-1}\epsilon_t = h(L)x_t + \alpha(L)^{-1}\epsilon_t$$

Focusing on the effect of one unit impulse in the absence of noise we can write:

$$y_t^* = h(L)(x_t + 1) = h(L)x_t + h(L)$$

where the function $h(L) = \sum_{k=0}^{\infty} h_k L^k$ shows the dynamic effects on output of the unit impulse for each lag of the exogenous variable. The sequence h_k, k=0,1,2... is therefore called *impulse response function* and $H_k = \sum_{j=0}^{k} h_j$ gives the *cumulative impulse response function* indicating how an unit impulse or a shock propagates to affect the output, starting in period t until the period t+k. The limit of the cumulative impulse response function is h(1) which is equal to the long run coefficient. It can therefore be said that the long-run coefficient is the asymptote of the cumulative function of the impulse response function. Having computed the impulse response functions, the long run coefficients and the cumulative impulse response functions of the considered model, the results are reported below.
It can be noticed that in all the cases the adjustment to the GDP variable takes place fast due to the low value of of $\hat{\alpha(1)}$ equal to 0,206278.

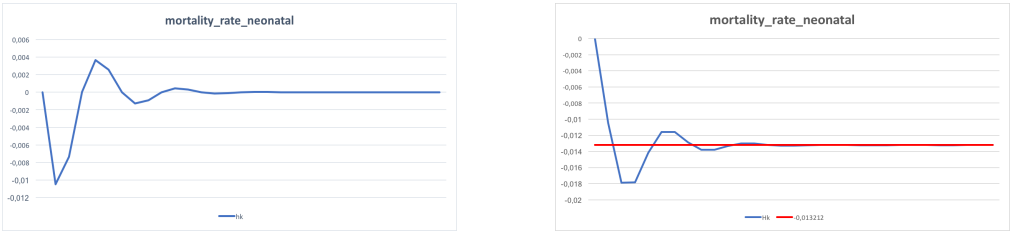


FIGURE 4.54: Impulse response function and cumulative impulse response function for mortality_rate_neonatal

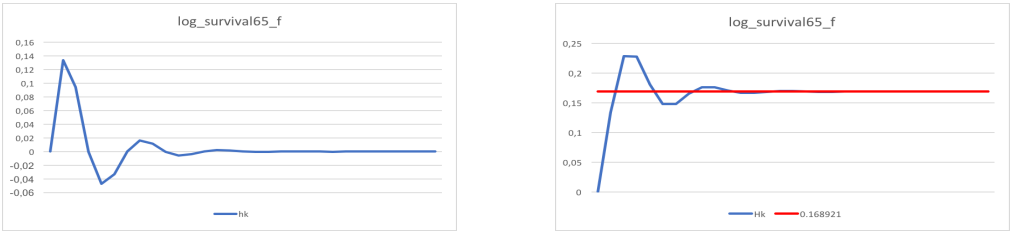


FIGURE 4.55: Impulse response function and cumulative impulse response function for log_surviva65_f

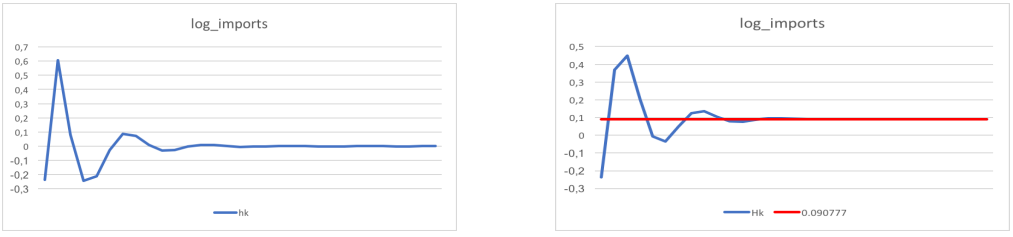


FIGURE 4.56: Impulse response function and cumulative impulse response function for log_imports

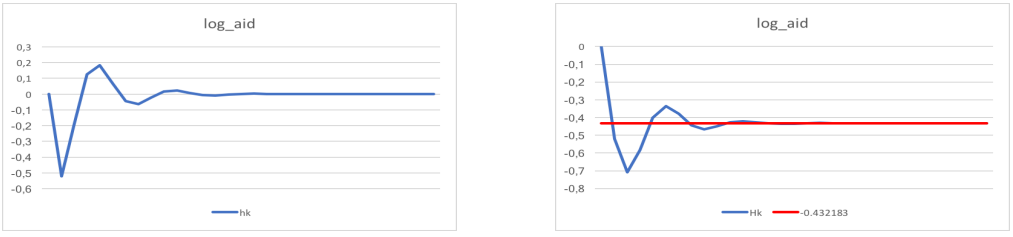


FIGURE 4.57: Impulse response function and cumulative impulse response function for log_aid

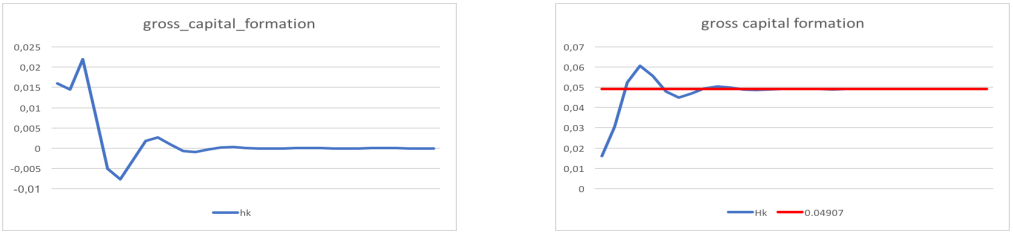


FIGURE 4.58: Impulse response function and cumulative impulse response function for gross_capital_formation

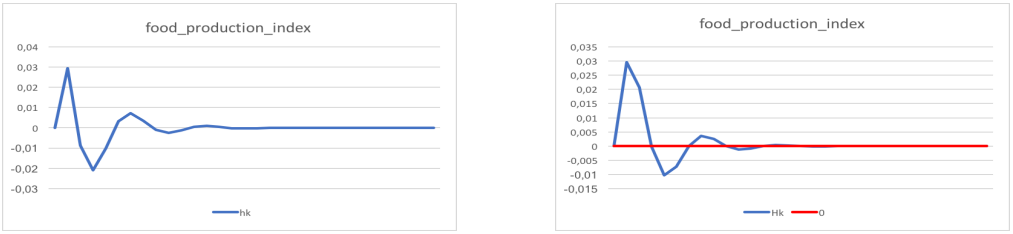


FIGURE 4.59: Impulse response function and cumulative impulse response function for food_production_index

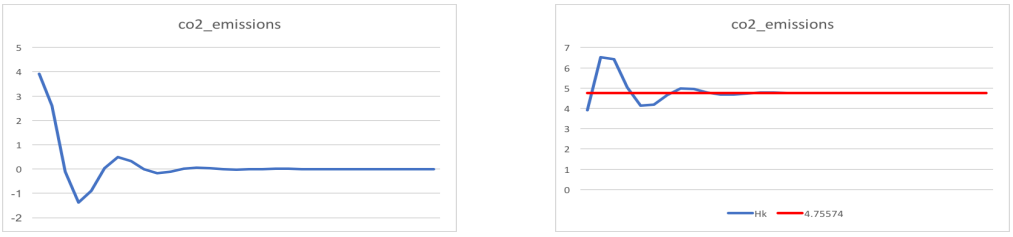


FIGURE 4.60: Impulse response function and cumulative impulse response function for co2_emissions

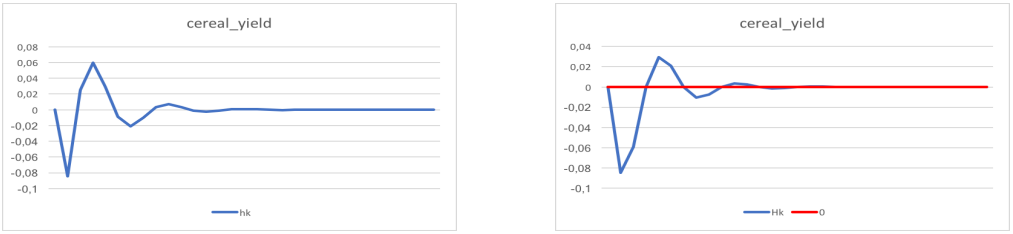


FIGURE 4.61: Impulse response function and cumulative impulse response function for cereal_yield

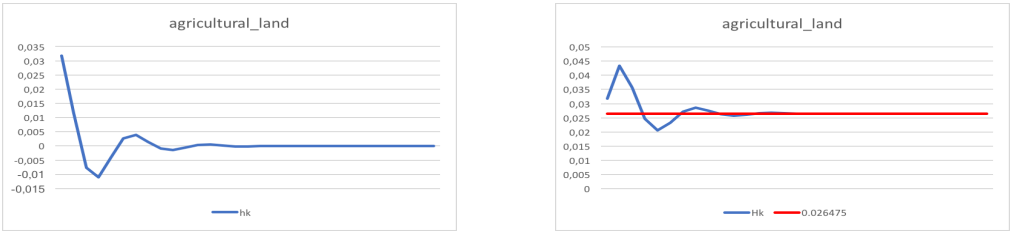


FIGURE 4.62: Impulse response function and cumulative impulse response function for agricultural_land

4.7 Forecasting

The last part of the analysis is the forecasting. As mentioned in the introduction, the sample has been divided in two parts, the first from 1961 to 2010 and the second one, called *virtual future* from 2011 to 2014, on which the forecast will be performed.

Firstly *static forecast* will be implemented: it foresees the endogenous variable's value in the time of forecast horizon, based on the available past values of explanatory variables and lagged endogenous variable. Given estimated model:

$y_t = \hat{\alpha} y_{t-1} + \hat{\beta}_0 x_t + \hat{\beta}_1 x_{t_1} + ... + \epsilon_t$

$t = 1, 2, ..., T$

then the static forecast is given by:

$\hat{y_{T+h}} = \hat{\alpha} y_{T+h-1} + \hat{\beta}_0 x_{T+h} + \hat{\beta}_1 x_{T+h-1} + ...$

$h = 1, ...T^* - T$

The dynamic forecast on the other hand foresees the endogenous in the forecast horizon on the basis of available past values of the explanatory variables and endogenous values forecasted in previous periods. Therefore we can write it as:

$y_t = \hat{\alpha} y_{t-1} + \hat{\beta}_0 x_t + \hat{\beta}_1 x_{t_1} + ... + \epsilon_t$

$t = 1, 2, ..., T$

$\hat{y}_{T+h} = \hat{\alpha} \hat{y}_{T+h-1} + \hat{\beta}_0 x_{T+h} + \hat{\beta}_1 x_{T+h-1} + ...$

$h = 1, ...T^* - T$

4.7.1 Long-run curve forecasting

The first forecast is computed using the reduced static regression model estimated in section 4.3. The forecast displays a Theil Inequality Coefficient very close to zero therefore a good forecasting

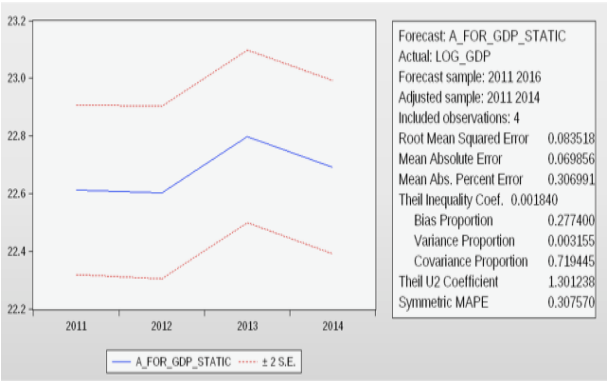


FIGURE 4.63: Forecast of Long Run static equation

power. The bias proportion is 0,277400: the mean of the forecast is slightly different from the one of the actual endogenous variable, while the variance proportion is close to zero. The covariance proportion is therefore around 0,71 indicating an high value of covariance among predicted and actual values.

In order to assess further the predictive performance of the model, the forecasted curve will be compared with the effective one. The deviation will be measured through the use of ad hoc built forecast intervals, that will work as critical intervals of a test. The two intervals have been built adding or subtracting to the forecasted value two times the standard error of the forecast:

$lgdp\_forecast\_sa\_up = lgdp\_forecast\_static\_a + 2 * se\_lgdp\_forecast$

$lgdp\_forecast\_sa\_dw = lgdp\_forecast\_static\_a - 2 * se\_lgdp\_forecast.$

The value 2 approximates 1,96 value defined by $Pr|\xi| < 1,96 = 0,05$, where $\xi \sim N(0,1)$. The forecast intervals therefore correspond to a confidence coefficient of 95%.

In our case the actual value of the variable log_gdp remains within the prediction intervals, but does not follow the increasing trend of the actual variable. The predicted log_gdp is consistent with the actual one on 2011, it is lower in 2012 and 2014 and higher in 2013.

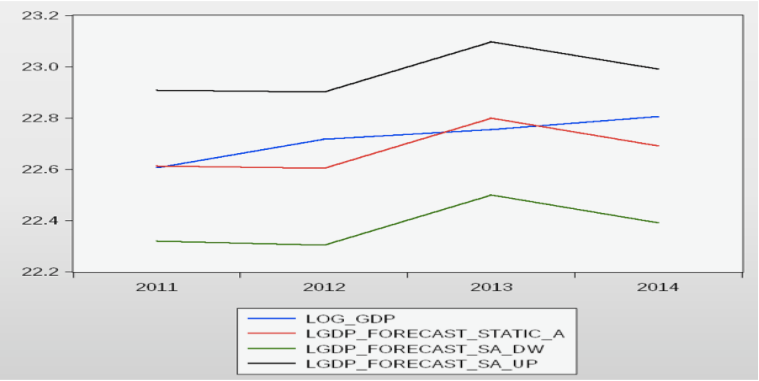


FIGURE 4.64: Test of goodness of static forecast

4.7.2 Forecast with the model in ECM form

4.7.2.1 Static forecast - dynamic model

The next step is the static forecast obtained from the dynamic equation estimated in the ECM form of secion 4.4. In this case, even if the Theil coefficient is still very close to zero, but now the

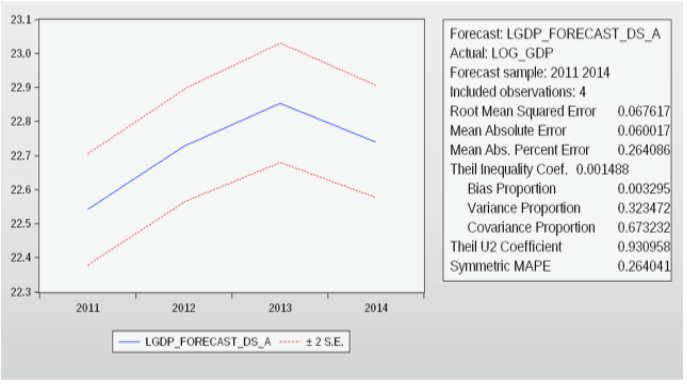


FIGURE 4.65: Static forecast of log_gdp from the dynamic equation

bias proportion is around zero while the variance proportion is around 0,32, with a consequent value of covariance proportion similar to the one of the static forecast from the static equation, 0,67.

Assessing the goodness of the forecast with the forecast intervals, we notice that again the forecast is inside the intervals, but this time displays in year 2011 and 2014 a lower value of the log_gdp actual variable, a higher value in 2013 and a similar value in 2012.

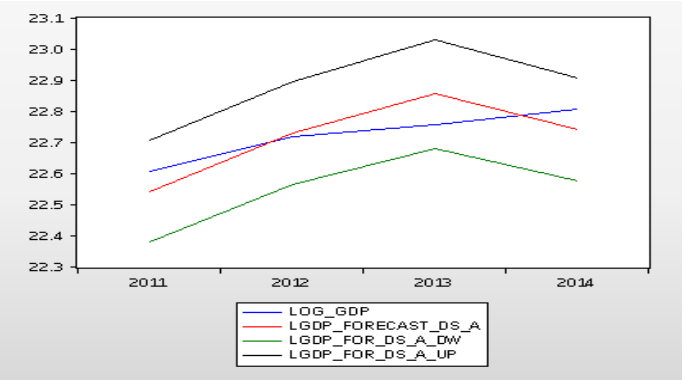


FIGURE 4.66: Test of goodness of the static forecast of log_gdp from the dynamic equation

4.7.3 Dynamic forecast - dynamic model

The last result is the one of the dynamic forecast obtained from the dynamic equation in the ECM form. It displays a value of Theil inequality coefficient very close to zero, but a covariance proportion of 0,21, due to an increase both in bias both in variance proportion.

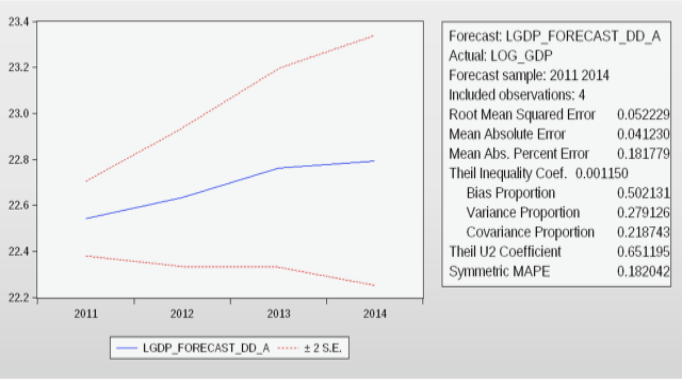


FIGURE 4.67: Dynamic forecast of log_gdp from the dynamic equation

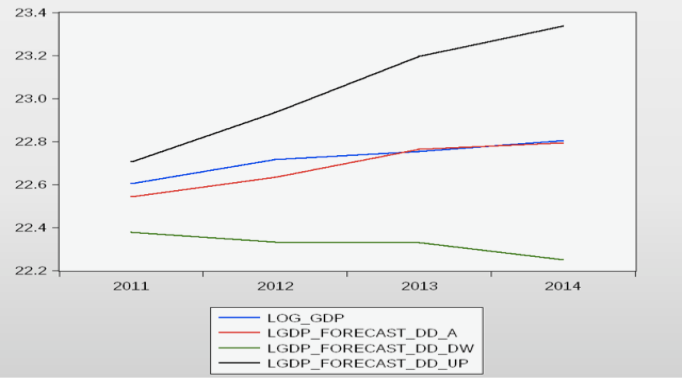


FIGURE 4.68: Test of goodness of the dynamic forecast from the dynamic equation

Looking at the test of goodness of forecast we can state again the forecasted values are inside

the forecast intervals and we can notice that the forecasted variable is lower than the actual one in 2011 and 2012, while their values overlap in 2013 and 2014.

4.8 Conclusions

The aim of this work was, on one hand, brining to light how a country characterized by a dramatic history and an instable economy has been able to achieve impressive results not only as far as economic growth is concerned, but also in the human development and health of its citizens. In particular, the econometric model, which is the core part of this study, was built in order to assess how the implementations of the ambitious plan of Rwanda 2020 have influenced the economic growth of the country. The methodology used in order to perform the study has been the following:

- a selection of panel data series coming from the World Bank datasets and Federal Reserve Bank of Saint Louis, covering at least the time period 1961 -2014 have been divided in clusters aimed to represent the pillars of the Rwanda 2020 plan
- normality test and Augmented Dickey Fuller test have been performed on the selected variables
- a static equation has been estimated using OLS method, considering as exogenous variables only the ones integrated of order one
- ADF test has been performed on the residuals of the static equation
- given the result of the residuals' analysis an ECM dynamic model has been estimated
- the analysis of residuals of the dynamic model has been performed
- impulse response functions and cumulative response functions were built for the exogenous variables
- static forecast on the long-run model has been implemented and tested
- static forecast on the short-run model has been implemented and tested
- dynamic forecast on the short-run model has been implemented and tested

The main weakness of the model is its inability to implement a broader analysis that considers as clusters of endogenous variables all the pillars considered in Rwanda 2020. Some important points addressed by the Rwandan Government, such as the development of a knowledge based economy, the regional and interregional integration and implementation of communication and ICT are not tested in the model due to the lack of suitable data. Other clusters, such as the education and the women's condition are excluded from the model due to the behavior of the datasets.

On the other hand, the results of the long run model highlight several interesting findings. The variables that have the highest impact on the GDP growth belong to the economic cluster and are log_aid and gross_capital_formation. The results are aligned with the Rwanda Economic Updated [World Bank 2017], that identifies as the main drivers of growth the high level of development aids and the large infrastructure spending, mainly aid-fuelled. The two determinants of growth are also considered one of the possible future weaknesses of Rwanda, whose economic dependency on foreign aid and public investment has already been one of the factors contributing to economic slowdown in 2016.

Another interesting finding is the result of the forecasts on the years 2011,2012,2013 and 2014. The years considered as the virtual future are characterized by a highly consistent GDP growth, that will slow in 2016 as an effect of global deceleration and coffee and tea prices crisis [World Bank 2017].

The static forecast obtained from the static model and dynamic forecast obtained from the dynamic model, despite the good values of the Theil Inequality Coefficients, seem unable to grasp the real trend of the endogenous variable: the result seems to be an empirical proof of the hypothesis of convergence: given the low starting level of GDP implies a high "catch-up growth", that tends to slow in 2016.

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