Population Growth and Economic Development in Burundi: Insights from Classical and Neoclassical Economic Growth Theories.

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The population of Burundi has experienced rapid growth, with a current rate of 2.7% as of 2022. Since 2001, the population has doubled, and if this trend continues unchecked, it is projected to double again by 2050. However, despite this demographic surge, incomes have been declining on per capita basis, leading to a decrease in purchasing power amidst rising costs of goods and services. Burundi's heavy reliance on subsistence agriculture, supporting around 90% of its population, exacerbates the situation. Unfortunately, agricultural productivity has not kept pace with population growth, resulting in food insecurity and contributing to economic stagnation. To delve into the impact of demographic growth on economic development, this study utilizes secondary data from the World Bank time series and the DHS 2016/2017. Using the Vector Error Correction Model and Linear OLS regression for time series analysis, and both linear and nonlinear probability models for fertility preference analysis, the study uncovers significant negative effects of population growth on cereal production per capita and real GDP per capita in both short and long term. Using DHS data, we find that people express a preference for fewer children than they currently have, with the ideal number being between 3 and 4. The study does not attribute Burundi's economic challenges solely to population growth. We argue that a multifaceted approach, which acknowledges the significance of classical and neoclassical growth theories, comprising population control—targeting a maximum of 3 children per woman—agricultural reform, and fostering a free and competitive market, could substantially bolster Burundi's socio-economic development.

[1] I am still collecting comments and feedback from different people to improve this paper!

Introduction

Growing Burundi's economy has been one of the main objectives of each government in its tenure. Despite the efforts, the growth of that economy has remained stagnant and vulnerable to shocks. Since its independence from colonial power, Burundi experienced several economic, security, and political turmoil, resulting in low and volatile economic growth while challenging the country's poverty reduction goals. That economic condition unpredictability has significantly discouraged the viabilities of entrepreneurship, innovations, and inflows of foreign and private domestic investments, which made the country stuck in a subsistence agriculture-based economic trap (Barro, 1991). The agriculture sector on which 90% of Burundians rely is still labor-intensive and subject to climate change and declining land supply caused by population growth and soil degradation. According to the production function, output is a function of labor, capital, and production factors such as technology and the quality of an institution. A surge in labor without enough capital and technology will result in diminishing returns per labor. The population of Burundi has been rapidly increasing with a slow increase in capital and factors of production, which has put the economy into diminishing returns and resource depletion situations, challenging structural transformation efforts.

The relationship between population growth and economic development is still controversial, despite a good amount of work on this topic. There is extensive literature on these relationships but little consensus on the actual effects of population on economic growth (Heady & Hodge, 2009). There is a lot of theoretical and empirical evidence showing how robust population growth is detrimental to economic growth, especially in low-income countries, due to a diminishing return. The other side of the literature proves a positive impact, whereas another group of economists has proven population and economic growth uncorrelated. The debate is still ongoing because economic growth is important for raising living standards around the world, and the role of population growth in the evolution of living standards is critical (Heady & Hodge, 2009). Population is a key parameter in economic growth model, it is always a good idea to assess how a demographic change affects the rest of the model in order understand how to better address that change. The assessment of the impact of population change on socioeconomic development should be on a country basis given each country's demographic and economic conditions. This paper addresses the question by closely focusing on Burundi. Burundi falls under that category of countries experiencing a diminishing return, especially in agriculture, which is the backbone of the Burundian economy. The study assesses population growth in conjunction with theories on capital stock, investments, technology advancement, and trade, raised by both classical and neoclassical growth scholars. Capital accumulation, a key component of economic growth, is primarily driven by savings, investments, and reinvestments, as demonstrated by classical growth economists such as Adam Smith, David Ricardo, and Karl Marx. The capital accumulation process in Burundi will be a result of both individual and national savings and investments, which will stimulate new business creation and innovation in various fields. A key component of avoiding diminishing returns in production is technological growth. However, technological growth is not driven by an abundance of labor, but by skilled labor and entrepreneurs and companies competing for their profit maximization. All that is driven by the abundance of capital, good governance, and high market demand in different sectors, which depends on how much people are spending on food, savings, and other needs. Lewis (1954) shows that industrial and agrarian revolutions always go together, so, economies in which agriculture is stagnant do not show industrial development.

The study analyzes population growth, resource accumulation, and agricultural production using both theoretical and empirical methods to examine to what extent high population growth without rapid technology advancement has affected economic development in Burundi, and whether population control would have an impact on people's living standards. This paper addresses the following questions:

1. Given the historical, political, and geographical situation of Burundi, how does population growth impact the economic development of the country in both the long-run and short-run?
2. What's Burundians' view on their fertility rate?
3. How can classical and neoclassical economic growth theories help us understand what Burundi falls short of and how to shape policies targeting economic development?

Using the error correction model (ECM), we observe both the long-run and short-run negative impact of population growth on both GDP per capita and cereal production per capita. We argue that, given the current and historical situation of Burundi, the high population growth is one of the major factors hampering economic growth and people's well-being. We recommend that a major economic reform, accompanied by measures encouraging family planning to target at most three children per woman, as this is the winning number from most of the women interviewed in 2016, would significantly reverse the economic narratives of Burundi. We also recommend institutional reforms to create a safe environment for both foreign and domestic investors, which will stimulate rapid technological adoption.

The rest of the paper is organized as follows: Section 1: Burundi's profile; Section 2: Literature review; Section 3: Theories of economic growth; Section 4: Data and resources; Section 5: Regression Models; Section 6: Empirical results and discussion; Section 7: Conclusion.

I. Burundi's profile

a. Geography and politics

Burundi is a landlocked country located in Central East Africa with steep mountainous terrain, a humid tropical climate, and a high plateau with altitude variation from 772m to 2,670m above sea level. The country took its origin in the 16th century as a small kingdom in the African Great Lakes region and kept expanding by annexing smaller neighbors in the subsequent centuries (BBC, 2023). That expansion culminated in a country with a total surface of 27,830 sq km, its land takes up to 25,680 sq km and the rest, 2,150 sq km, is occupied by water (CIA, 2023). Burundi was under a monarchic political regime since its foundation, disrupted by European colonial power since the late 19th century. A colonial regime ruled Burundi for more than half a century, initially by Germany, and then by Belgium following the end of World War I. Following the independence from Belgium in 1962, Burundi has maintained a republican system of government ever since. In the years following the independence, the country was plagued by a series of ethnic and political conflicts, leading to several civil wars and coups that claimed the lives of half a million people[2] (Baltissen, 2012, Nkurunziza & Ngaruko, 2005).

b. Economic Overview

Burundi's colonial exploitation, followed by a series of political and security crises, has significantly hampered sustainable economic development. Growth of national domestic income has not been stable since the 1960s and the growth rate has never been above 5% on average since

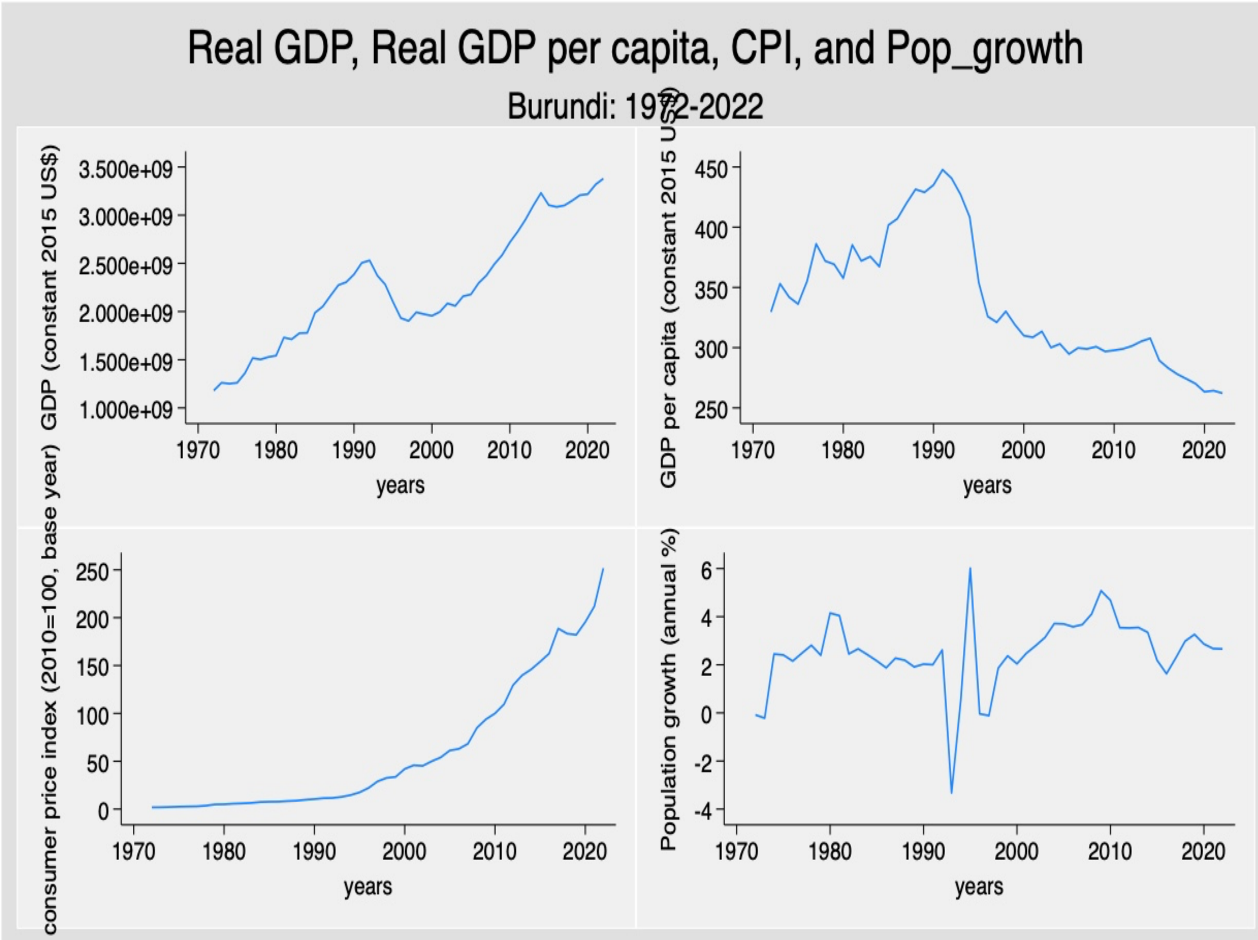
[2] As Nkurunziza and Ngaruko show, it all began in the 1960s, when the monarchy was replaced by a republic, and leaders, inheriting divide-and-rule colonial practices, began to fracture society along ethnic lines, which led to iterative cycles of violence.17 Successive leaders imposed a strong military rule in which ethnic affiliation became a critical factor in determining alliances, thereby eroding traditional caste-based governance mechanisms. In 1972, following Hutu uprisings in the south, Tutsi forces killed many Hutus. From then on, Burundian society was divided in a Manichean fashion. In 1992, a new constitution led to unrest between the two communities, and in 1993, following the assassination of President Ndadaye (the first Hutu and first democratically elected president) by Tutsi officers, violence became generalized. Hence, conflicts of the second part of the 20th century were primarily driven by political considerations that trickled into civilian strife.

1990 (Figure 1). The national GDP has been very sensitive to security shocks and Figure 1 shows sharp declines in GDP occurring during the timeline of those security crushes, characterized by intense civil wars and political conflicts (Baltissen, 2012). On average, per capita real income[3] has been shrinking, making life increasingly difficult to navigate in Burundi. The decline in real income per capita is caused by an increase in inflation, coupled with the population outgrowing the country's income. The World Bank's latest reports show that the inflation rate hit 26% in July 2023, from an annual average of 18.8% in 2022, due to a rise in prices of fuel and food (World Bank, 2023). However, this surge in inflation has been a common issue globally due to the COVID-19 pandemic and the ruso-Ukrainian conflicts, which negatively affected the supply chain. Burundians are very impacted by the rise in inflation because prices increase disproportionately with the rise of people's income. Prices of goods and services in Burundi have been skyrocketing, totaling a consumer price index of 250 as of 2022 from less than 10 in 1980 (Figure 1). If prices go up faster than people's income, their purchasing power declines and makes a larger portion of the household's income spent on food[4]. Demand in other sectors, investments, and savings crunch, which paralyzes the entire economy and people's living standards. This low savings and investment rate among the majority of citizens is partly responsible for Burundi's ranking as one of the world's least developed countries. Human Development Index ranks the country 187th out of 189 nations in 2021, from the place of 183rd in 2010, showing that the country has failed to escape its economic backwardness and catch up to the rest of the world (World Bank, 2023).

Figure 1: Population growth and economic growth over time

[3] Real income per capita is a per capita income adjusted for inflation.

[4] See Ernst Engel's law developed in 1857 stating that lower income families spend a larger portion of their budget on food than wealthier ones. As income rises, spending on food makes up a smaller part of the budget and spending on other goods and services increases.



Note. On the top left, is the annual real GDP growth since 1972. GDP growth (annual %) in Burundi was reported at 1.849 % in 2022, according to the World Bank collection of development indicators, compiled from officially recognized sources. On to right, real GDP per capita; has been declining since 1990. Bottom left, Burundi's CPI from 1972-2022; base year, 2010, CPI = 100. There is a 10% average annual CPI index growth since 1965. Data source: World Bank, World Development Indicator.

Burundi's economy is still trapped at the subsistence level due to its heavy reliance on subsistence agriculture. More than 90% of Burundians rely on agriculture, and it is the main sector employing many people; agriculture represents 40% of the national GDP and covers more than 30% of total export revenue (CIA, Keringingo & Kayakayaci, 2023)[5]. Due to its predominantly subsistence-based structure, this farming-based economy is susceptible to climate and

[5] According to Keringingo and Kayakayaci's publication (2023), Burundi is a major exporter of coffee (21%) and ranks the second after gold exports (49%). Burundi also exports tea (8%), wheat(4%), processed food(1%), and Tobacco(1%) (See Grebmer et al.,2020)

demographic shocks (BTI, 2022). Agriculture is carried out on 46.7% of the country's land area, with the majority (44%) carried out on slopping hills and dominated by small farms, with 86% of households cultivating on plots less than 0.5ha (MINAGRIE, 2012). Due to heavy rain on those densely exploited sloppy plots, soil erosion is getting worse and escalating soil degradation, with a high probability of an increase in sediment loss up to 69% by 2030[6] (Tall et al.,2022). Burundi loses annually 1.6% of its GDP to land degradation; the World Bank analysis estimated that Burundi loses almost 38 million tons of soil per year, for $120 million in 2014, or 3.9 percent of GDP (Tall et al., 2022)[7]. This predominance of the country's hilly landscape makes it hard for agricultural expansion and mechanization, which is another factor contributing to agricultural productivity slippage (Collins et al., 2013).

The country's poor infrastructure contributes to the economy's fragility and backwardness. Burundi has a very low rate of electrification in the region, ranking last on the list[8]. Less than 12% of the entire population has access to electricity, among which 3.5% live in rural (Tall et al., 2022). This low electrification poses big issues for the economies in general and poses lots of barriers to the quality of education and healthcare. Poor electrification, along with poor roads, makes communication harder, and challenges agriculture improvement efforts in rural areas, home to more than 80% of the population.

c. Burundi's Demographic Overview

[6] If the detected trends continue, sediment loss could increase by 69 percent by 2030 from 2020 levels, and by up to 200 percent by 2050.

[7] From 2017 to 2020 alone, more than 33,000 ha—1.2 percent of Burundi's land area— experienced acute degradation; Burundi loses 5.2% of its land area every year to soil degradation since 2020

[8] Burundi ranked No. 54 out of 54 on the AfDB's Electricity Index in both 2019 and 2020. See AfDB, 2020, "The Africa Infrastructure Development Index (AIDI) 2020."

Burundi is one of the most densely populated in Africa[9]. It is home to 12.9 million people as of 2022, which doubled since 2001 and is expected to double again by 2050. Burundi is among the countries with the highest population growth in the world, even if the rate of growth has been slowly declining since 1972 (World Bank, 2023). For the last 10 years, the population has been constantly growing at a higher pace than the GDP growth (Figure 1), implying a declining GDP per capita. With this average declining income per individual, using the most recent survey data available for Burundi (2016/2017), the UNDP reports that 75.1% of the population in Burundi is "multidimensionally poor" while an additional 15.8% is classified as vulnerable to multidimensional poverty in 2021[10]. According to the World Bank, more than 60% of the population is young, ready, and able to work, but still under critical economic conditions. The majority of the population relies on soil production for food and energy, which depletes resources as the population grows. People in both rural and urban areas depend on solid biomass (wood and charcoal), which accounts for 90% of energy usage in Burundi (AFBD, 2019). This poses a great threat to the forest sector, which accounts for 11% of Burundi's total land area, according to FAO, and is expected to keep declining as the population increases. Not only the forestry sector, increasing in population has significantly led to a sharp decline in arable land, from 0.25 ha per person in 1972 to less than 0.1ha per person as of 2022 (Figure 3).

II. General literature review

[9] At 463 persons per km2, Burundi's population density is almost 10 times the average for Sub-Saharan Africa. See https://data.worldbank.org/indicator/EN.POP.DNST?locations=ZG-BI.

[10] According to the UNDP, the global Multidimensional Poverty Index (MPI) measures acute multidimensional poverty across more than 100 developing countries. It does so by measuring each person's overlapping deprivations across 10 indicators in three equally weighted dimensions: health, education and standard of living (see figure). The health and education dimensions are based on two indicators each, while standard of living is based on six indicators. See https://hdr.undp.org/sites/default/files/Country-Profiles/MPI/BDI.pdf for more details.

In less than two centuries, the world's population has increased by more than six times. Around 7.9 billion people live in the world today, up from less than 1.2 billion people in the 1850s (World Bank, PRB, Todaro & Smith). The rapid growth of the population is primarily occurring in developing countries and is expected to continue at a high level for the remainder of the century (PRB). More than 75 million people are being added to the world's population. Almost all of this net population increase, around 97%, is in developing countries (PRB, Todaro & smith 2013, p85). Demographers and economists were deeply concerned about this rapid increase in population growth, which motivated their investigation of its relationship to economic development. Since the Malthus (1766-1834) era, a lot of models and theories around this topic have been developed, which are important to review in this study. During that period, the world's economy was largely based on agrarian and labor-intensive activities, so Malthus was concerned that an increase in population could cause a vicious cycle of boom and bust, resulting in famine due to resource depletion (Malthus, 1789). Malthus' nightmare led to the emergence of three different schools of thought: pro-Malthusian, anti-Malthusian, and neutral.[11]

Neo-Malthusian theories showing how rapid population growth was detrimental prevailed since the 1950s. Those neo-Malthusian scholars use exogenous growth models,[12] showing that lack of capital or saving and a surplus of labor in agriculture are major constraints on economic growth (Birdshall, 1989). The exogenous models provide explanations that there is a negative relationship between population growth and GDP per capita growth, as first pioneered by Solow (1956). Solow's results are backed by the findings by Robin (1994) in his research to uncover

[11] Pro-Malthusian thoughts are those who improved on his ideas and don't disagree with him; Anti-Malthusian: those whose ideas regarding population growth and economic growth were completely different from Malthus'; Neutral: those who don't find any relationship between population growth and economic growth.
[12] The exogenous growth theories states that economic growth is driven by influences outside the economy. External factors primarily determine economic prosperity. The exogenous growth model factors in production, diminishing returns of capital, savings rates, and technological variables to determine economic growth.

more correlation between population growth and economic growth using data from 86 countries grouped based on their income status. Using the OLS regression analysis model with 3 variables such as GDP per capita growth, population growth, and lagged fertility, he finds a negatively significant correlation happening for low-income subgroups. Robin finds an adverse effect of population growth on economic growth due to an increase in the denominator of the per capita income ratio, a reduction in saving rates due to a high dependency ratio, and a reduction in the female labor force (Robin 1994). Robin's conclusion is not different from Coale and Hoover's (1958) finding when studying labor supply in the case of high fertility, with a focus on resource allocation as well. They found that due to factors such as a high dependency ratio, high fertility will lead to a lower proportion of those in the labor force, which then results in lower income per capita; they also find a resource-dilution effect due to an increase in a denominator of per capita resource ratio (Coale and Hoover, 1958). In their study with a sample from 144 countries, Barlow finds a negative correlation after adding lagged fertility to the rate of population growth as a second predictor (Barlow, 1994).

Unlike exogenous theories, endogenous models prove a positive effect of population surge on economic activities. As Shackleton (2013) notes, the development of endogenous[13] growth models resulted from residual thoughts associated with technological advancement after neoclassical growth models had accounted for labor and capital effects. These models suggest that there is a positive relationship between population growth and economic development as opposed to neo-Malthusian growth models (Peterson 2017). This conclusion is consistent with works done by different scholars, such as Kutznets (1966), and Simon (1989), whose results attest that

[13] The endogenous growth theory is an economic theory which argues that economic growth is generated from within a system as a direct result of internal processes. Endogenous growth theory focuses on the role that population growth, human capital, and the investment in knowledge play in generating macroeconomic growth. The theory is built on the idea that improvements in innovation, knowledge, and human capital lead to increased productivity.

population growth is a positive contributor to economic growth. Simon points out that the empirical studies of the relationship between population growth and economic development may be interpreted based on standard "canons of scientific practice". In her reserved observation from other scholars' findings, drawing a positive relationship between higher population density and higher economic growth, she points out that this effect might be strongest at a low density, but there is no evidence that the effect reverses at a higher density (Simon, 1989). The theoretical idea behind these conclusions from those who are optimistic about the effect of population growth on economic growth is that a high population stimulates economies of scale and technological advancement. Boseryp (1965, 1981), focusing on agriculture, suggests that an increase in population density can cause a shift to a more labor-intensive farming system; this shift will require each worker to work long hours causing a diminishing return to labor. Boserup argues that this shift will prompt farmers to come up with new technologies to increase their productivity, which then results in technological advancement caused by the pressure of this demographic increase. Lewis (1954) and Fei (1964) added to Boseryp's idea by treating population growth as exogenous. They argue that the surplus of labor from farming is absorbed into manufacturing only if saving and capital grow faster than population, or if technological change in manufacturing offsets the combined effects of diminishing returns in agriculture and population growth. The idea that population growth can encourage technological innovation and economies of scale can also happen through other ways independent of rapid population growth, such as economic policy (Birdsall, 1989). Birdsall challenged Coal and Hoover's pessimistic findings by asserting that if there is sufficient technological progress responsive to factors of scarcity and thus labor-intensive, additional labor can lead to increases in per capita income even without equivalent growth in capital (Birdshall, 1989).

While many economists find either positive or negative effects of population growth, a movement of some revisionist economists finds no correlation. It was by the mid-1980s that those economists in the revisionist movement adopted a more neutral stance on population growth (Kelly 2001). In their study published in 1998, Dawson and Tiffin used annual time series data over the period 1950-93 to analyze the long-run relationship between population and economic growth in India. The study employed co-integration and Granger causality methods and reported that there is no long-run relationship between the two variables. This means that population growth neither Granger causes economic growth nor is caused by it. Using the same method as Dawson and Tiffin, Thornton (2001) conducted similar research on the long-run relationship between population and economic growth in seven Latin American countries (Argentina, Brazil, Chile, Colombia, Mexico, Peru, and Venezuela). Using the annual series data over the period 1900-94, he concluded that there is no significant long-run relationship between population growth and economic development in any of those countries.

That neutral position inspired other scholars to avoid aggregations and start doing country-specific analysis to assess the effects of population growth on per capita economic growth. It is not universally true that a higher population leads to higher innovation and then higher income. If that were the case, the highest-growing population regions like sub-Saharan Africa and Asia would be among the highest-income regions. It is then important to approach this issue in the context of each country because countries have unique factors affecting their economies. It is due to that uniqueness that the effect of population growth on economic development tends to be different across countries. In his article, Peterson (2017) uses historical data to chart the links between population growth, growth in per capita output, and overall economic growth over the past 200 years. He finds that low population growth in high-income countries is likely to create social and economic problems, while high population growth in low-income countries may slow their development. According to the reviews by Headey(2009), Kelly (1988), McNicoll (1984), Srinivasan (1988), and Birdsall (1988), population growth has adverse effects only in some countries, especially in those with lower economic development and in countries with "ineffective" or "inappropriate" policy or institutions. Headey's study finds that the partial association between population growth and economic growth will be more positive when the regression controls for the quality of policies and institutions, what he calls the " institutional interactions' hypothesis" (Headey 2009). In this paper, we aim to avoid aggregation bias by conducting a country-specific analysis, focusing on Burundi's unique characteristics to examine the effects of population growth on socio-economic development.

III. Theories of economic growth

a. Classical economic growth theories

Classical economic growth theories took place during the 18th century and were a combination of economic work done by Adam Smith (1729-1790), David Ricardo (1772-1823), and Thomas Malthus (1766-1834) (Harris, 2007). These theories place more emphasis on the finiteness of resources than on technological and institutional change and the accumulation of physical and human capital (Jolly and Torrey, 1993). Adam Smith emphasizes the division of labor, going hand in hand with capital accumulation through savings and reinvestment of profits from their investments, as a critical factor of economic growth. He argues that the accumulation of capital will result in the availability of very specialized tools and equipment that would allow workers to further specialize and thereby improve their productivity and dexterity. Adam Smith's work inspired Ricardo's interest in economic questions, which led him to develop theories and literature that contributed to the economic world. Ricardo's theory of growth focuses primarily on capital accumulation, with a diminishing return in agriculture. The English economist Thomas Malthus developed a theory of population, believing in diminishing returns in agriculture. His theory emphasizes that economic growth and betterment of the population are not possible without a strong limit on reproduction (Malthus, 1798). Malthus found that population increases geometrically while food production increases only arithmetically; this would make the population surpass its production capacity and run out of food. He thinks that this would lead to starvation and other issues like wars, famine, and diseases, which would reduce the population to a manageable level and the cycle would begin anew. Smith believes that increasing in population leads to an increase in labor, which, accompanied by the division of labor, will lead to higher economic growth, at least in the absence of emerging limitations (Spengler, 1970). Both Smith and Malthus agree that food was the ultimate limitation factor determining populousness, since, given food, people could easily find 'the necessary clothing and lodging'[14]. Ricardo's theory does not avoid the idea that rapid population growth could depress wages to the subsistence level, which could limit profit and capital formation (Spengler, 2023). Given the pre-industrial period of those classical growth models, they tend to ignore technological advancement as a manner to offset the impact of population growth.

The neo-Malthusian movement has been dominated by thinkers who have built upon and elucidated his ideas, emphasizing the depletion and scarcity of resources caused by overconsumption as one of the primary causes of ecological collapse, resource scarcity, and lower

[14] This is quoted from Smith's book, "Wealth of Nation"(page 163); introduction by Robert Reich ; edited, with notes, marginal summary, and enlarged index by Edwin Cannan. New York :Modern Library, New York (1993). See Spengler, 1997.

per capita income. Among the neo-Malthusian thinkers, Paul Ehrlich emphasizes the environmental consequences of population growth in his model. He points out that the human population is moving fast toward environmental collapse due to over-usage, and pollution; he thinks that zero population growth is crucial (Ehrlich, 1968). In his publication of 1990, he argues that high population growth, especially, in low-income economies forces people to live on a subsistence level of income. His argument was complemented by Nelson (1956) showing that as long as per capita income remains below a critical level, a population growth that exceeds the per capita income growth would properly lead the economy to a low-level equilibrium trap. They advocate that population control through family planning is critical. Neo-Malthusian theories had an influence on population policies in some developing countries at that time like China and India with respectively one child-policy[15] (1979-2015) and sterilization (1975-77), as well as other measure population policies that are going on even until today (Follett, 2020).

b. Neoclassical economic growth theory

The neoclassical growth theories emphasize supply-side factors such as technology, capital, and labor to determine the rate of economic growth. These theories explain the growth process using Robert Solow's production function, $Y = AF(K, L)$ (1) which means that aggregate output or GDP (Y) is in the function of capital (K), labor (L) and multiplicative technology factor (A). This neoclassical model assumes a constant return to scale, which means that a percentage increase in input (labor or capital) leads to the same percentage increase in output. Change in

[15] In 1979, the Chinese government formally initiated the OCP to alleviate social, economic, and environmental problems such as the high unemployment rate and scarcity of land resources. The policy used birth quotas to control population growth. As the results, the urban fertility rate fell drastically over a short period of time—from on average 3 per family in the early 1970s to just about 1 in the early 1980s (Choukhmane. Et al.2014). The policy has been beneficial in terms of curbing population growth, aiding economic growth, and improving the health and welfare of women and children (see T. Hesketh and W. X. Zhu). Household saving as well as human capital drastically increase since 1979.

technology leads to change in marginal productivity of both labor and capital, leading to a shift in production function. Since not all the factors contribute to the growth of income at the same level, it is important to include each factor's level of contribution in the model.

$\Delta Y = \Delta AF(K,L) + MP_k.\Delta K + MP_L.\Delta L$ (2). MP_k: Marginal product of capital; MP_L: Marginal product of labor. We get equation 3 below by dividing both sides of the equation by Y,

$\frac{\Delta Y}{Y} = \frac{\Delta AF(K,L)}{Y} + \frac{MP_k.\Delta K}{Y} + \frac{MP_L.\Delta L}{Y}$ (3)

From equation (1), let's replace the Y under the first term on the right-hand side with its equivalent, and multiply and divide by K and L in the first and second term respectively. $\frac{\Delta Y}{Y} = \frac{\Delta AF(K,L)}{AF(K,L)} + \frac{K.MP_k.\Delta K}{Y.K} + \frac{L.MP_L.\Delta L}{Y.L}$

$\frac{\Delta Y}{Y} = \frac{\Delta A}{A} + \frac{K.MP_k}{Y} \times \frac{\Delta K}{K} + \frac{L.MP_L}{Y} \times \frac{\Delta L}{L}$ (4)

$K\frac{MP_K}{Y} = \alpha$: share of capital in national income; $L\frac{MP_L}{Y} = 1 - \alpha$: share of labor in national income.

This leads us to the Solow accounting growth equation, which is expressed as:

$\frac{\Delta Y}{Y} = \frac{\Delta A}{A} + \alpha\frac{\Delta K}{K} + (1-\alpha)\frac{\Delta L}{L}$ (5), which can be equal to Cobb Douglas production function: $Y = AK^{\alpha}L^{1-\alpha}$

The economic growth of a country is determined by technological progress, growth of capital multiplied by capital weights or share in income, and growth of labor multiplied by labor weight or contribution to total productivity.

Unlike the Malthusian model, the Solow growth model shows that population growth is positively related to economic development. This conclusion is supported by a large number of neoclassical scholars such as Todaro (1993), Eberstadt (1986), Simon (1981, 1982), and Hansen (1993) who argue that a larger population increases the demand to stimulate economies of scale in production. However, believing only that a higher population will lead to higher income can be misleading because many other factors must be met to make the relationship realistic. Adam Smith agrees that an increase in population that goes hand in hand with a division of labor and a capital increase will lead to higher production per labor, which would lead to higher output. An increase in labor without an increase in productivity per labor will result in diminishing returns, leading the economy into a Malthusian trap, assuming a constant technological contribution. Even if those neoclassical scholars believe that population pressure and economies of scale are more likely to stimulate technology and innovation, it is harder to progress in technology without skilled labor or human capital, which is an important factor that is missing in the Solow model. Including human capital, a growth model then looks like this: $Y = AF(K, L, H)$. This growth theory that includes the contribution of human capital started in the 1960s in the work of Becker, Schultz, and Friedman[16] (Mustafa, 2019). Thus, population growth would positively affect economic growth if those people turned into skilled workers, with access to capital, ready to substantially grow productivity and avoid falling into the diminishing return trap.

c. Theories within the context of Burundi

Classical growth theories emerged when England and Europe were predominantly agrarian economies. As the Industrial Revolution prevailed, neoclassical thinkers started considering technological advancement as one of the powerful factors of economic growth that could even offset the impact of population growth on economic growth raised by Malthus and his supporters. It was more significant to all these economic thinkers to figure out how to grow the economy at another level given the country's endowment in that period. Classical and neoclassical theories

[16] See Theodore W. Schultz, 'Capital Formation by Education', Journal of Political Economy, 6 (1960), pp. 571- 583. Gary S. Becker, Human Capital: A Theoretical and Empirical Analysis with Special Reference to Education (Chicago, The University of Chicago Press, 1993), p. 16.
Friedman, M., and Friedman, R., Free to Choose: A Personal Statement (New York, Harvest Books, 1990).

are still relevant to Burundi, and they can serve as useful guides for economic reform. Burundi is currently facing a situation that emphasizes the resource-dilution effect in Neo-Malthusian theories. The technological advancements that challenged Malthusian predictions and prevented diminishing returns in Europe have not been able to exist in Burundi, which has kept the economy relying on subsistence agriculture. Increasing the population without increasing agriculture production results in food scarcity, lowering savings and capital accumulation that would enable the country to adopt and/or develop new technologies. According to neo-Malthusian scholars, Burundi is facing major constraints on economic growth due to that lack of capital or savings and a glut of labor in agriculture whose marginal return is diminishing. In their study, Nkurunziza et al.(2012) found that Burundi's investment performance is much below the sub-Saharan average and below its peers in the East African Community. In addition to the failure to mobilize domestic savings, Burundi has also attracted little private capital and continues to depend heavily on official development assistance whose unintended consequence is Dutch disease, making the tradable sector less competitive[17]. This diminishing return in agriculture is not only caused by a lack of capital but also limited arable land supply, which is also subject to degradation, climate change, and poor infrastructure.

The positive association between labor growth and economic growth, as stated by neoclassical theories, has not been realistic in Burundi. Instead, Burundi is experiencing significant growth in labor with no growth in capital, resulting in a decreasing marginal return per

[17] Dutch disease is an economical way of describing the paradox which occurs when inflow of resources/money, such as the discovery of large oil reserves, foreign aids, etc., harms a country's broader economy by negatively affecting tradable sectors, resulting in lower exports and economic activities. According to Investopedia, the term Dutch disease was coined by The Economist magazine in 1977 when the publication analyzed a crisis that occurred in The Netherlands after the discovery of vast natural gas deposits in the North Sea in 1959. The newfound wealth and massive exports of oil caused the value of the Dutch guilder to rise sharply, making Dutch exports of all non-oil products less competitive on the world market (see the economist journal here: ECON-1977-1126: Dutch Disease)

labor and a declining income per capita, despite all efforts to enhance agriculture[18]. Both classical and neoclassical theories emphasize the importance of capital (both physical and human) accumulation to economic growth. Adam Smith himself believes that an increase in population should go hand in hand with a division of labor (which is a form of increasing labor's dexterity) and capital accumulation to equip skilled labor with enough technology to boost output. Burundi's economy has already fallen into what Nelson (1956) calls "a low-level equilibrium trap" given that income per capita has been growing against population growth and a low rate of capital accumulation due to high employment in subsistence agriculture. What Burundi needs today falls under what Rebelo (1991) said that to produce perpetual growth, there must be a factor or a combination of factors that can be accumulated indefinitely without diminishing returns. To achieve that, population control through family planning[19] and a focus on capital accumulation, human capital, and technological advancement are paramount to the sustainable development of a nation.

IV. Data and sources

This study uses two types of secondary data sets. The first one is a multivariate time series collected by the World Bank from 1972 to 2022. In this study, we selected this World Bank data set since it contains almost all the variables that we are interested in. Our primary goal was to analyze data from 1962, the beginning of the post-colonial period of Burundi, to 2022; but due to data limitations, it was necessary to begin with 1972. To get a sense of the prices of goods and

[18] See: https://2017-2020.usaid.gov/burundi/agriculture-and-food-security

[19] Limiting population growth should be the main economic policy that can be followed by other majors such as institutional changes, agriculture reforms, and promoting capital accumulation and technology advancement. Without a limit in the population, capital accumulation will not be possible at individual level for many Burundians, especially those relying on subsistence agriculture and wages. Food will remain scarce due to land scarcity and technological advancement (machinery) in agriculture that is not applicable at 44% of arable land and not attainable to the majority of farmers.

services' trends over the past 50 years, we merge consumer price index (CPI) data sourced from the U.S. Federal Reserve Economic Data (FRED) from 1972 to 2022 to the World Bank data. The World Bank data set contains 51 observations, and each observation represents one year. The World Bank data is used in lots of studies, and it is trusted by researchers and economic analysts, which is the reason the World Bank provides the collected data as an open source for users.

The second dataset is the 2016/2017 Demography and Health Survey household data, the most recent survey available for Burundi. We use this dataset because it contains other variables that we cannot find in the World Bank data, and it is also based on household levels across different provinces. The results from this data would be complementary with the World Bank data results to better give a clear answer to the research question. World Bank data can be compared to macro-level data since it provides a national representation of the variable on an annual basis. Microdata is provided by DHS household data because they provide information at the household level. Having both macro and microdata for this study will facilitate extensive analysis. The whole household survey dataset (2016/2017) has 45, 419 observations, with households as a unit of observation, but the study uses 34, 147 observations. Our studies incorporate these observations because we are especially interested in women's views on fertility and population growth in general when making policy recommendations. This decision was also driven by the fact that 75% of all the participant households in the survey have men as household heads and 75% (34,147) of those who responded are wives of the household heads. So, including 75% of this dataset allows us to perfectly capture all women and their husbands' ideas from the survey.

V. Methodology/ Econometric Models

We examine women's fertility preferences and the impact of population growth on the economic growth of Burundi using two different data sets. We use linear, linear probability, nonlinear probability, and Vector Error Correction models to gauge the potential relationship between the variables of interest. We estimate coefficients from the linear and linear probability models using Ordinary Least squares (OLS). The general OLS econometric function Y given X is given by the following equation: $Y = f(X_1, X_2, \ldots\ldots\ldots\ldots\ldots\ldots, X_k) + \varepsilon$.

The equation shows Y, a dependent variable as a function of X, a set of regressors X_{ik}----X_{ik} , but acknowledging that not all the factors of Y are depicted in X. All the factors that cannot be quantified in X are included in the error term ε. We model this function as a linear combination of variables, which gives the below general ordinary least square (OLS) econometric model.

$Y_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \ldots\ldots\ldots\ldots + \beta_k X_{ik} + \varepsilon_i$ (1) : i=1,…n, where,

- Y_i is i^{th} observation of the dependent variables; $X_{i1}, \ldots\ldots, X_{ik}$ are the i^{th} observation of each of the k regressors; $\beta_0 \ldots \beta_k$: unknown parameters or regression coefficients of each regressor; and ε_i is random error or error term.

There are, however, some limitations to OLS when dealing with time series data. By using OLS for the time series, we will not be able to capture the full reality of the relationship between the variables. A time series can trend together, but it is not necessarily correlated; a series can be stationary or not; a series can have a stochastic or deterministic trend. Using only OLS without detecting the nature of the series would impact the robustness of the results because the OLS assumes stationarity (Stock and Watson, 2020). As Granger and Engle (1987) argue, linear regression for analyzing time series, especially when nonstationary, can lead to spurious correlation[20]. To avoid falling into that trap, we run a stationarity test analysis by plotting the series and running the Augmented Dickey-Fuller test (ADF). Then, we test for cointegration, as introduced and suggested by Engle and Granger (1987), which allows us to use the Vector Error Correction model (VECM) to study short-run and long-run relationships between the series. We use the VECM model for the time series and the linear and probit model for the HDS data.

For the time series, we use a Vector Error Correction model with 3 endogenous variables or series such as lnrpGDP, which is the natural log of real GDP per capita in US$; pop-growth, which is population growth with an annual growth rate; and lnCPC, natural log of cereal production per capita. There are numerous reasons why we include cereal production per capita in the model. Using only real GDP per capita, even if it is a good indicator of economic growth, will not allow us to fully capture people's living standards over time. This is because the Burundian economy is highly agriculture-based, with 90% of the population relying on the sector. Burundians rely on Cereal and tubers for domestic food consumption. Cereals (Maize, rice, sorghum, etc) are the main source of energy, and they can be kept for long periods given the low food processing level in Burundi. So, people can stock cereal, as a good way of saving their food budget. Including food production in the model would help alleviate aggregation bias caused by income inequality and inequality in production, while also understanding the role of agriculture in the economic growth and well-being of the Burundian citizens. We also acknowledge that Burundians consume imported cereal, but locally produced cereal plays a major role in the economy of the country, and it is a good indicator of agricultural performance as well as rural economy.

[20] Spurious correlation occurs when variables are deemed causally related due to coincidence or unknown third factor, making the whole results unreliable.

We compute Cereal production per capita (CPC) using two series, such as cereal yield (cereal production, kg per hectare) and arable land[21] (hectare per person). Due to the unavailability of data about land under cereal cultivation each year, or generally land under cultivation, we use arable in the formula, which is closely similar to land under cultivation.

$CPC\ = cereal\ yield\ \ X\ arable$, which is the same as

$\frac{Cereal\ Production}{Hectare}\ X\ \frac{Hectare}{Person} = \frac{Cereal\ Production}{Person}\ or\ CPC.$

This equation works under the following assumptions:

- A person's arable (land under active and consistent agriculture exploitation) is used up for cereal production. This is because we are not able to find data for land under cereal crops over time.
- A farmer makes a rational trade-off before each agriculture season. If they don't use the land for cereal, they are growing something else that can replace the cereal.

The lnCPC, lnrpGDP, and pop-growth are the 3 co-integrated variables of order 1 that we use in the VECM model. Given 3 co-integrated variables Y, X, and Z, the general model is expressed as $\Delta Y_t = \alpha + \sum_{i=1}^{p-1} \beta_i \Delta Y_{t-i} + \sum_{n=1}^{p-1} \delta_n \Delta X_{t-n} + \sum_{j=1}^{p-1} \gamma_j \Delta Z_{t-j} + \lambda_1 (Y_{t-1} - \theta_1 X_{t-1} - \theta_2 Z_{t-1}) + u_{1t}$

With

- P-1 shows that the lag length is reduced by 1
- β_i , δ_n, γ_j Short-run coefficients of the model's adjustment equilibrium

[21] According to FAO, Arable land includes 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. FAO does not consider land abandoned due to shifting cultivations as arable. Due to land scarcity in Burundi, there are no longer frequencies of meadows and fallow land.

- λ :speed of adjustment parameter
- $Y_{t-1} - \theta_1 X_t - \theta_2 Z_{t-1}$: error correction term or ECT
- u_t: residual or stochastic error terms, also called impulse.

The VECM(P) with P=number of lags=2 is modeled as VECM(P-1) and the 3 equations are presented below.

$$\Delta RpcGDP_t = \alpha_1 + \beta_1 \Delta RpcGDP_{t-1} + \delta_1 \Delta CPC_{t-1} + \gamma_1 \Delta Popgrowth_{t-1} + \lambda_1 ECT_{t-1} + u_{1t}$$

$$\Delta CPC_t = \alpha_2 + \beta_1 \Delta RpcGD_{t-1} + \delta_1 \Delta CPC_{t-1} + \gamma_1 \Delta Popgrowth_{t-1} + \lambda_2 ECT_{t-1} + u_{2t} \qquad (3)$$

$$\Delta Popgrowth_t = \alpha_3 + \beta_1 \Delta RpcGDP_{t-1} + \delta_1 \Delta CPC_{t-1} + \gamma_1 \Delta Popgrowth_{t-1} + \lambda_3 ECT_{t-1} + u_{3t}$$

Each equation has a dependent variable whose regressors include its first difference and the two other endogenous variables. Using those equations, we will be able to analyze both short-run and long-run relationships between the endogenous series.

For the DHS data, we use a linear model, LPM, and probit regression model. The linear model's coefficients are estimated using the following equation:

$$Ideal\_childnum = \beta_0 + \beta_1 educ\_partner + \beta_2 rural + \beta_3 wealthy + \beta_4 age\_respo + \beta_5 catholic + \beta_6 non\_educ + \beta_7 \; non\_educXeduc\_partner + \varepsilon \qquad (1)$$

The left-hand variable (dependent variable) is "ideal-child-num", which is an ideal number of children. The independent variables are education of the respondent partner (Educ-partner); rural: a regional dummy variable, which is equal to 1 if a respondent lives in a rural area and zero otherwise; wealthy=1 if the respondent's household is "wealthy" and 0 otherwise; age of the respondent (age-respondent); religion of the respondent(a dummy variable "Catholic"=1 if the participant is catholic and zero if they are not; a dummy variable "Non-Educ"=1 if the respondent has no education at all and zero otherwise; and interaction between non-Educ and partners' education.

To model the relationship between the categorical dependent variable with the regressors, we use both linear probability (LPM) and nonlinear probability model (probit). We generally want to understand the predicted probabilities that Y=1 given X as given the population regression function, $E(Y/X) = Pr(Y = 1/X)$.

We express the general linear probability model as follows,

$Pr(Y = 1|X_1, X_2, \ldots\ldots\ldots\ldots\ldots\ldots, X_k \ ) = \beta_0 + \beta_1 X_1 + \ldots. + \beta_k X_k$; We estimate the coefficient (beta) using OLS. The coefficients are the differences in the probabilities that Y=1 associated with a unit change in X. We use OLS to estimate those coefficients using the following model:

$Pr(Xmore\_child = 1|X_1 \ldots\ldots. X_8) = \beta_0 + \beta_1 educpartner + \beta_2 tchildren + \ \beta_3 rural + \beta_4 wealthy \ + \beta_5 age\ respondent \ + \ \beta_6 catholic \ + \beta_7 non - educ \ + \beta_8 noneducXeduc\_partner + \varepsilon.$

However, the LPM has certain limitations when dealing with binary dependent variables. Probability cannot be below 0 or exceed 1, so the effect of the probability that Y=1 given X has to be nonlinear (Stock & Watson, 2020). The LPM cannot capture the nonlinearity nature of the population regression function because it is not necessarily constrained within the [0,1] interval. To ensure flawless results, Stock and Watson recommend using both linear and non-linear models to compare results from both models.

We express the nonlinear model, probit, as follows:

$Pr(Y = 1|X_1, X_2, \ldots\ldots\ldots\ldots\ldots\ldots, X_k \ ) = \Phi(\beta_0 + \beta_1 X_1 + \ldots. + \beta_k X_k \ = \pi \ )$(2) With $0 < \pi > 1$; The dependent variable Y is a binary: $Y \ = \{0,1\}$, Φ is a standard normal distribution cumulative function, $X_1 \ldots X_k$ are the regressors, $\beta_0$and β_1 are unknown parameters to be estimated for the model. We model the non-linear relationship between our variables of interest using the following equation:

$$Pr(Xmore\_child = 1 | X_1, \ldots\ldots\ldots X_k)$$
$$= \Phi(\beta_0 + \beta_1 educpartner + \beta_2 tchildren + \beta_3 rural$$
$$+\beta_4 wealthy + \beta_5 age\ respondent + \beta_6 catholic + \beta_7 non - educ +$$
$$\beta_8 noneducXeduc\_partner) + \varepsilon. \qquad (2)$$

This equation models the probability that a respondent does not want more children given the given covariates. The dependent variable is "Xmore-child", which is equal to 1 if a respondent that represents a household "i" does not want more children and zero otherwise. The covariates in this model are pretty much the same as the ones used in the linear equation except for the addition of "t-children", the respondent's total children ever borne.

VI. Results

We use both descriptive statistics and econometric techniques in this study. The descriptive analysis consists of computing summary statistics of the variables used in the models, creating tables, and visually representing relationships between variables. Econometric techniques consist of running different regression models in Stata to estimate the unknown parameters, and beta, and assess their statistical significance in hypothesis testing.

As Burundi's population grew astronomically without a steady increase in their source of income and progress in their production functions (technology), their economy grew slowly. Due to the slow income growth coupled with a higher population growth rate, income per person has consistently declined since 1972, with a compounded annual growth rate of -0.45% and -1.6%

since 1990, resulting in lower average living standards and consumption (Figures 3). Figure 4 illustrates how arable land, the main asset of Burundians, has increased from 0.9 million hectares to 1.2 million hectares. However, due to a high population growth rate, arable land per person has declined from 0.25 hectares to less than 0.1 hectares. As a result, cereal production per person has decreased by around 45% since 1972. The behavior of cereal production can also give us an idea of how other crops are doing. Despite the lack of specific data, decreased cereal production per capita implies a substantial probability of decreasing returns in other crops, which can also be explained by the constant rise in food prices (both imported and domestic).

Figure 3.

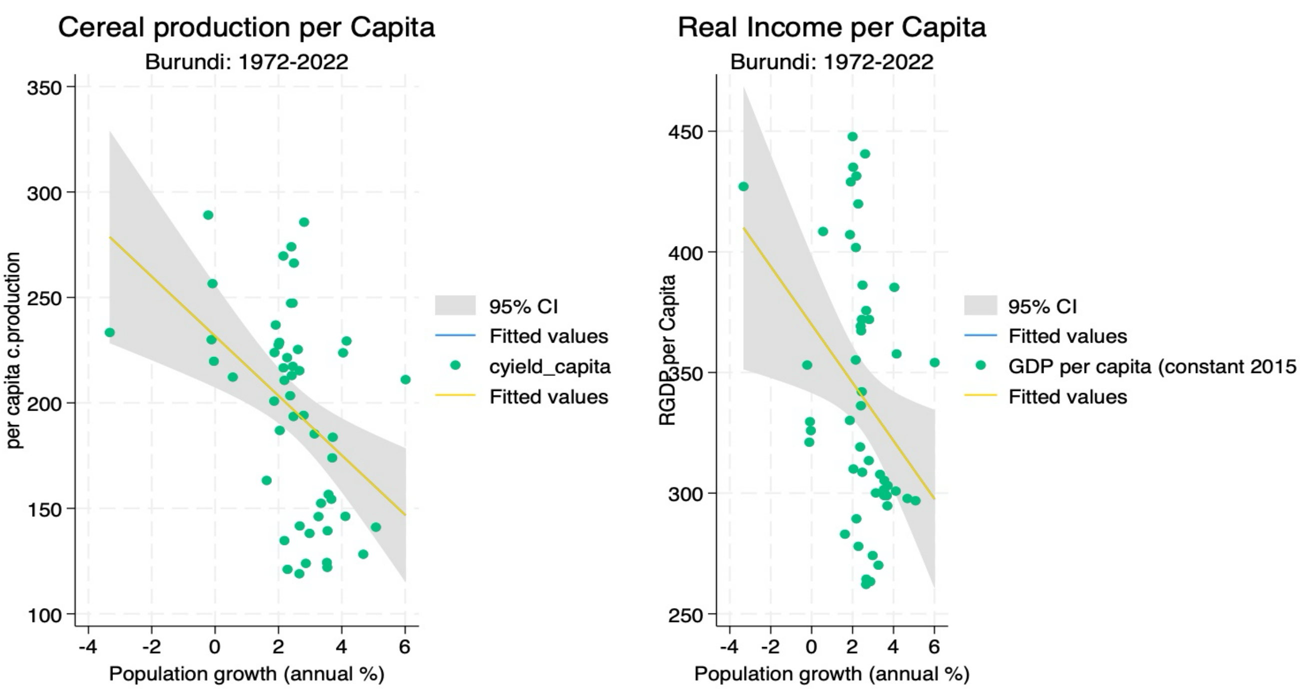
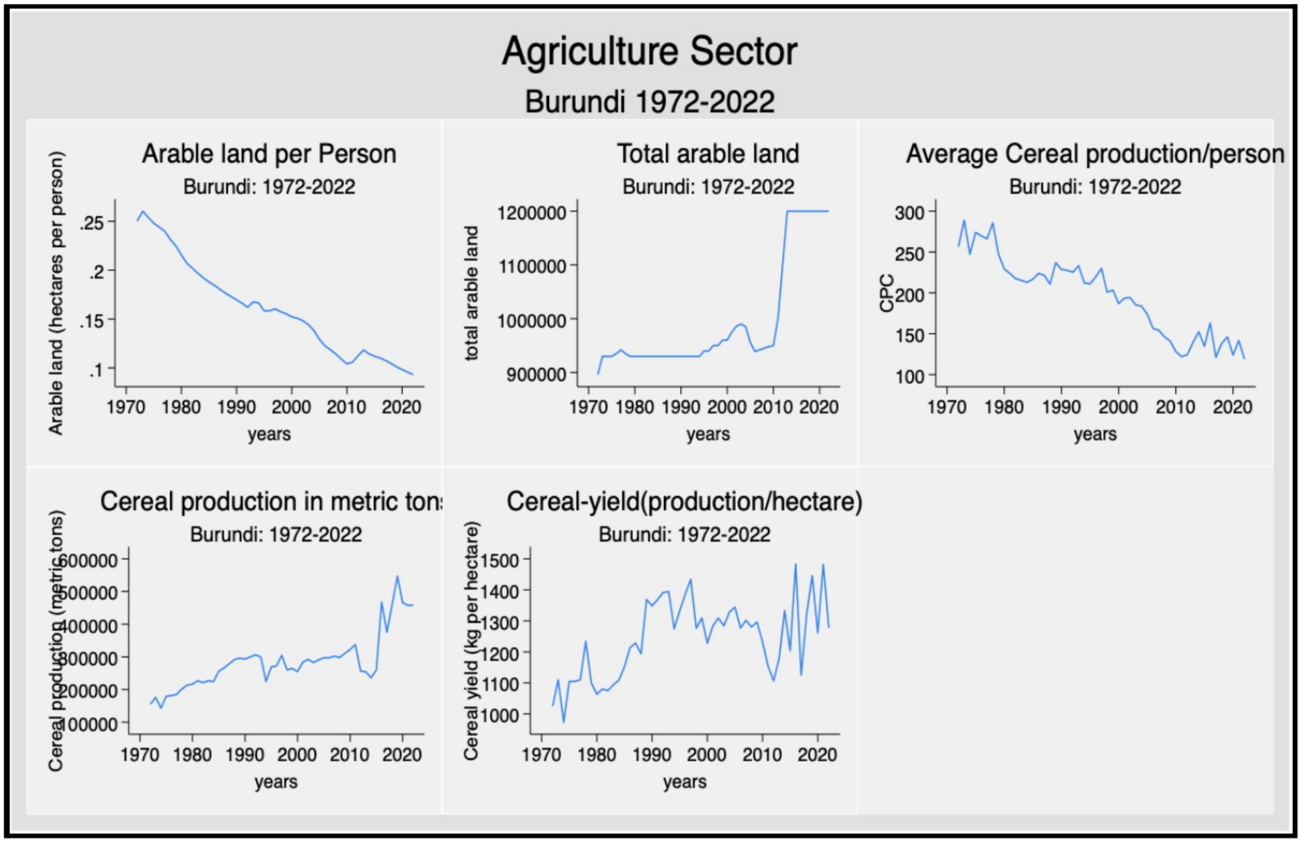


Figure 4



Note. Burundi's total area is 27,830 sq km, which is equal to 2.783 million hectares, among which land accounts only for 2.568 million hectares. Arable land has increased from 900,000 ha in 1972 to 1.2 million hectares as of 2022. As of now, arable land accounts for 1.2/2.568 = 46.7% of the total land area. 80% land, potential agricultural land.

VEC Model Results

We get the VECM results after a series of tests. We first test stationarity to know whether the variables have a unit root or not. We test stationarity in two ways, using data visualization (plots) and the Augmented Dickey-fuller test(ADF), developed by Dickey and Fuller (1979, 1989). To run an ADF test, we must find the optimal lag order of each variable, in the first place, using information criteria, such as Akaike's information criterion (AIC), Schwarz's information criterion (SIC), and Hannan-Quinn's information criterion (HQ), respectively proposed by Akaike(1969, 1973), Schwarz(1978), and Hannan and Quinn(1979). We carefully use information criteria as well as test different scenarios using other lag orders to avoid potential biases. As Liu (2007) points out, including too many lags can reduce the power of the test to reject the null hypothesis, making the ADF test weaker in detecting unit root, while also causing degrees of freedom loss. Also, if the lags are too small, the unit root inference is biased (see Schwert, 1989). The results are presented in the tables below:

Figure 5. Non-stationary series, I(1)

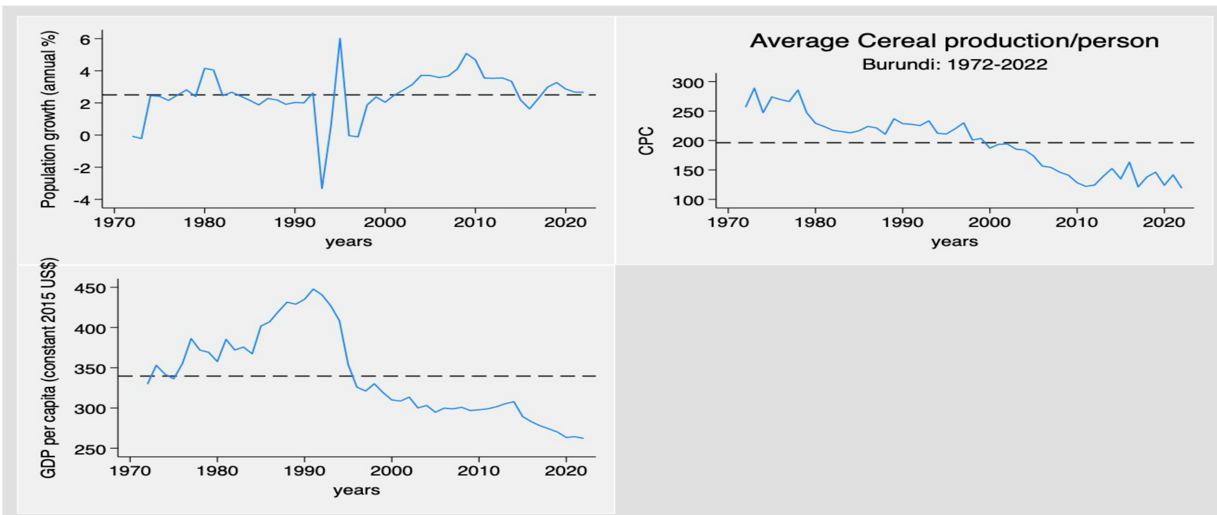
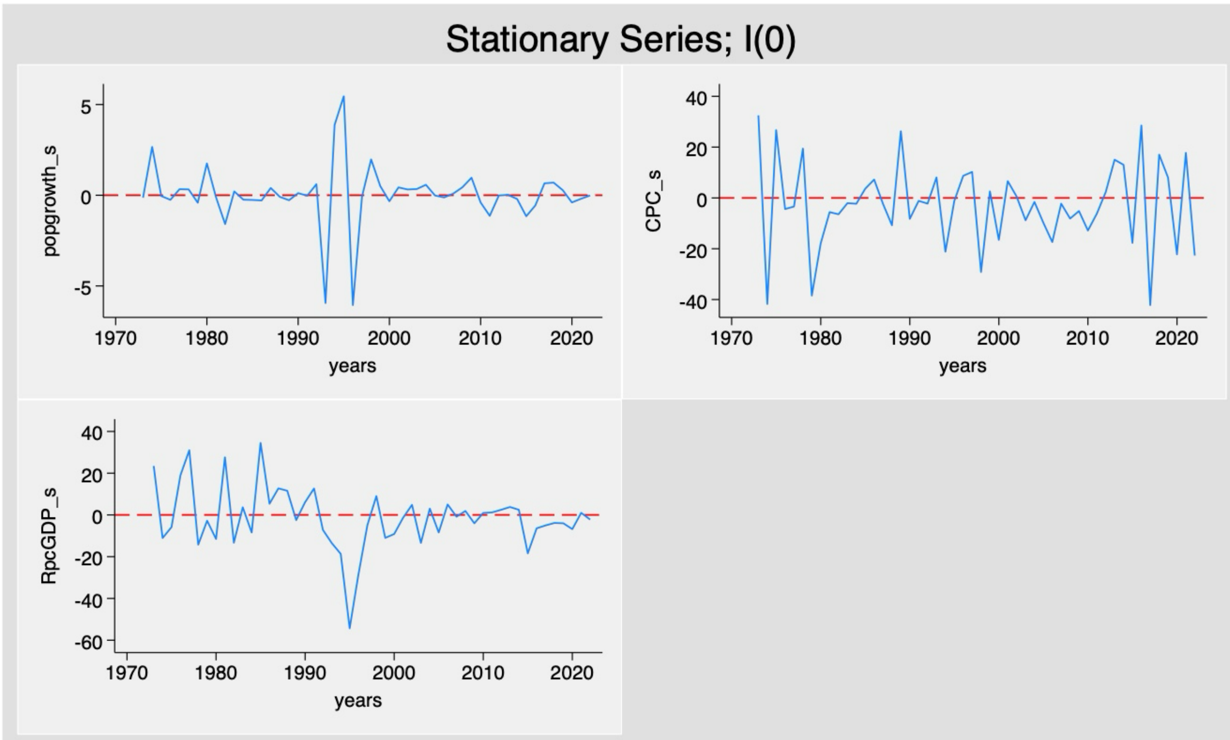


Table 1: Dickey-Fuller Test results

				Dickey-Fuller critical value		
Variables	**lag order**	**P-value**	**T-statistic**	**1%**	**5%**	**10%**
lnrpGDP	2	0.3697	-2.419	-4.168	-3.508	-3.185
lnCPC	2	0.5601	-2.075	-4.168	-3.508	-3.185
Pop_growth	2	0.3930	-2.375	-4.168	-3.508	-3.185

The p-values of all these variables are greater than significance levels, meaning that none of these variables are stationary or integrated at order 0, I(0). Both the results and the graph above also show that the series has a stochastic trend. The series are I(1) or are integrated of order 1, meaning that to make them stationary, we have to differentiate them once and the results are presented in Figure 6.

Figure 6, I(0)



After the first difference, the series are integrated of order 0, or they are stationary. This proves that our original variables share similar non-stationary properties: they are all integrated of order 1, which means they are all integrated into levels but stationary at the first difference, as presented in Figure 6. These series characteristics motivate us to test whether there is a long-run co-movement of the series. So, we test for Johansen cointegration. The Johansen cointegration test is used here because it allows us to use more than one cointegrating series, as we have 3 series of interests.

Before the cointegration test, we ran an information criteria test for the series to find the optimal lag length, and the results are presented below. Using HQIC, FPE, and SBIC criteria, the optimal lag length is 2. This allows us to run a cointegration test using the second lag. As presented in table 2, the trace statistics, show a cointegration at rank 1, meaning that there is one independent linear combination of the stationary variables. This means that there is a connection between these variables over time, that should not be ignored. There is one cointegrating relation between variables, which allows us to run a Vector error correction model to study the long-run relationship between the variables. The long-run cointegrating equation or ECT can be expressed as $ECT_{t-1} = Y_t - \theta_1 X_t - \theta_2 Z_t - \theta_0$, which corresponds to $ECT_{t-1} = 1.000 lnrpGDP + 1.082 lnCPC + 0.697 popgrowth - 13.334$ (See table 6)

θ_1 and θ_2 are cointegrating coefficients if $Y_t - \theta_1 X_t - \theta_2 Z_t$ is stationary.

Table 2. Lag- order selection

Lag-order selection criteria

Sample: **1982** thru **2022** Number of obs = **41**

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-27.6139				.000894	1.49336	1.53902	1.61874
1	53.4097	162.05	9	0.000	.000027	-2.01999	-1.83736	-1.51845
2	71.4708	36.122	9	0.000	.000017*	-2.46199*	-2.14239*	-1.58431*
3	80.0938	17.246	9	0.045	.000018	-2.4436	-1.98702	-1.18977
4	83.421	6.6543	9	0.673	.000025	-2.16688	-1.57333	-.536893
5	97.2897	27.738	9	0.001	.000021	-2.40438	-1.67385	-.398243
6	102.956	11.332	9	0.254	.000027	-2.24174	-1.37424	.140547
7	106.1	6.2881	9	0.711	.000041	-1.95608	-.95161	.802354
8	111.189	10.18	9	0.336	.000062	-1.76534	-.623895	1.36925
9	125.411	28.442	9	0.001	.000066	-2.02003	-.741617	1.4907
10	138.668	26.514*	9	0.002	.000086	-2.22769	-.812302	1.65919

* optimal lag
Endogenous: **lnrpGDP lnCPC pop_growth**

Table 3. Cointegration test results

```
Johansen tests for cointegration
Trend: Constant                                          Number of obs  = 49
Sample: 1974 thru 2022                                   Number of lags =  2
--------------------------------------------------------------------------------
                                                                      Critical
Maximum                                                    Trace         value
   rank   Params           LL   Eigenvalue            statistic            5%
      0       12    58.700069            .              43.3485         29.68
      1       17     76.42234      0.51488               7.9039*        15.41
      2       20    80.361503      0.14852               0.0256          3.76
      3       21    80.374298      0.00052
--------------------------------------------------------------------------------
* selected rank
```

We have a VECM with 2 lags or VECM(2), but the results in the table below are estimated with the first lag, VECM(1).

Table 4. VECM(2)

	Dependent variable		
Regressors	**D_lnrpGDP**	**D_lnCPC**	**D_PopGrowth**
L._ce1	0.017**	0.008	-1.478***
	(0.01)	(0.02)	(0.24)
	(2.40)	(0.51)	(-6.04)
LD.lnrpGDP	0.134	-0.044	10.317*
	(0.13)	(0.29)	(4.48)
	(1.01)	(-0.15)	(2.30)
LD.lnCPC	0.043	-0.546***	-2.046
	(0.06)	(0.13)	(2.03)
	(0.06)	(-4.17)	(-1.01)
LD.pop_growth	-0.011**	-0.004	0.225
	(0.00)	(0.01)	(0.14)
	(-2.63)	(-0.46)	(1.66)
_cons	-0.004	-0.024*	-0.000
	(0.01)	(0.01)	(0.18)
	(-0.75)	(-2.08)	(-0.00)
r2	0.2009	0.3213	0.5172
N	49	49	49

Note. L.c1 is the correction error coefficient and it has to be between -1 and 0 otherwise the correction term is explosive, and the negative sign indicates the degree of correction. The ECT measures the speed of adjustment toward long-run equilibrium; it indicates the speed of recovery from short-run disequilibrium/distortion(the last period's deviation from a long-run equilibrium of the co-integrated series) to long-run equilibrium convergence. The magnitude of the coefficient suggests a fairly high speed of adjustment in the aftermath of a shock. If greater than 1, imply oscillatory convergence. It has to be negative to indicate correction of the previous disequilibrium or shocks within the model. We use a 5% significance level. Heteroscedasticity- robust standard errors are given in parentheses under coefficients and the second parenthesis indicates t-values. The stars indicate statistical significance where *,**, and *** respectively represent 10%, 5%, and 1% significance levels.

Table 4 presents the results from the Vector Error Correction Model that includes 3 endogenous variables Real GDP per capita, Population growth, and Cereal production per capita. The table represents the short-run relationship between the variables. The results show that the past value of cereal production per capita is associated with the current value, and it is significant. An increase in cereal production in the past is associated with a decrease in the present. A possible explanation for this behavior is land scarcity. Due to continuing land degradation and declining arable per capita, crop rotation, especially maize is highly practiced, which can lead to cereal output fluctuation. Land scarcity and small capital investment in agriculture are among the factors contributing to the marginal return per labor. We also observe a short-run negative relationship between population growth and real GDP per capita. A one-unit increase in population growth is associated with a 1.1% decrease in real income per capita on average, ceteris paribus.

The long-run relationship is presented in the tables 5 and 6. We have shown that the series in our model are co-integrated; in Table 4, we see a statistically significant correction error coefficient, -1.478, which indicates the speed of adjustment toward the long-run equilibrium of the co-integrated series. As presented in Tables 5 and 6, high population growth has an asymmetric impact on economic development in the long run-on average, ceteris paribus. Population growth is negatively associated with per capita income and cereal production, with statistically significant coefficients.

Table 5: Results for long-run relationship test

Johansen normalization restriction imposed

beta	Coefficient	Std. err.	z	P>|z|	[95% conf. interval]	
_ce1						
lnrpGDP	1	.	.	.	.	.
lnCPC	1.082116	.51201	2.11	0.035	.0785948	2.085637
pop_growth	.6971178	.1024061	6.81	0.000	.4964054	.8978302
_cons	-13.33469	.	.	.	.	.

Table 6

Johansen normalization restriction imposed

beta	Coefficient	Std. err.	z	P>|z|	[95% conf. interval]	
_ce1						
lnCPC	1	.	.	.	.	.
lnrpGDP	.9241154	.7339931	1.26	0.208	-.5144846	2.362715
pop_growth	.6442173	.0896362	7.19	0.000	.4685336	.819901
_cons	-12.32279	.	.	.	.	.

Regarding diagnostic tests for the model, we tested for overall short-run causality between the series, and we found a statically significant, at 5% level causality. We also checked autocorrelation between lag order and we found no autocorrelation. To test residual normality, we run a Jarque-Bera test and the results show that the residuals are normally distributed for the first two equations (lnrpGDP and lnCP) but not normally distributed overall; We also perform a stability test and the vector is stable with 2 unit moduli. We finally tested for heteroscedasticity and the series are homoscedastic.

OLS, LPM, and Probit Model Results

We thoroughly test for collinearity and heteroscedasticity on both linear and probit regression models to ensure the robustness of our results. With robust regression, we can eliminate any sort of variance instabilities that would compromise the results' reliability.

Descriptive analysis is drawn from Summary Table (ST) 1-6 and Figure A1 (See the appendix). Figure A1 depicts a negative relationship between a husband's educational level and the total number of children ever born. The number of children in households with less than five years of education remains relatively higher, even though it is still mostly higher among those with higher levels of education. Regarding women's fertility preference from the survey, approximately 62% of women who responded do not want more children, 85% live in rural areas, 56% are Catholic, and 55% did not finish primary school. The survey indicates that women should ideally have four children on average, even though, on average they have six children. The descriptive findings regarding fertility preferences prompt some considerations: a significant portion of women within the 62% who do not desire more children may have already reached their desired family size or are unable to conceive due to health issues or menopause. How do younger participants view the prospect of having four children compared to older respondents who may already have numerous offspring? To mitigate such uncertainties, we stratify respondents based on age groups, with 64% falling under the age of 40 and 36% aged 40 or older.

Both groups prefer having four children on average, which reveals their kin desire to maintain small families. Among respondents under 40, 87% prefer to have between 3 and 6 children, with 51% expressing no desire for additional children. Ninety-one percent of respondents have given birth to between one and seven children, averaging five children per respondent. In contrast, 84% of respondents aged 39 and above have given birth to between 5 and 10 children, and it's not surprising that 84% of them do not wish to have more children. Despite the high average number of children, which stands at 8 per woman, 90% of respondents express an ideal number of children ranging from 2 to 6, with 30% specifically desiring four children. These findings suggest that Burundians generally do not favor having numerous children, even when they find themselves in larger families that exceed their preferred size.

Table 7: LPM, Probit, and LM

	Y, dummy variable: xmore_child		**Y, continuous: ideal_chilnum**
Regression Model	**LPM(1)**	**Probit (2)**	**LM(3)**
Educ-partner	-0.003***	-0.008***	-0.004
	(0.00)	(0.00)	(0.00)
	(-3.35)	(-3.01)	(-1.40)
T-children	0.057***	0.191***	
	(0.00)	(0.01)	
	(43.63)	(38.06)	
Rural	-0.016**	-0.056**	0.131***
	(0.01)	(0.02)	(0.03)
	(-2.24)	(-2.31)	(4.60)
Wealthy	-0.025***	-0.080***	0.360***
	(0.01)	(0.02)	(0.02)
	(-5.07)	(-4.69)	(19.10)
Age-respondent	0.016***	0.046***	0.005***
	(0.00)	(0.00)	(0.00)
	(35.56)	(30.27)	(4.33)
Catholic	0.073***	0.245***	-0.284***
	(0.00)	(0.02)	(0.02)
	(15.46)	(15.52)	(-15.58)
Non-educ	-0.048***	-0.131***	0.099***
	(0.01)	(0.02)	(0.02)
	(-7.40)	(-6.02)	(4.10)

Non_educXeduc_partner	0.006***	0.018***	0.002
	(0.00)	(0.00)	(0.01)
	(4.37)	(3.77)	(0.35)
_cons	-0.264***	-2.317***	3.782***
	(0.01)	(0.05)	(0.05)
	(-18.03)	(-46.03)	(70.04)
r2	0.250		0.021
N	34,147	34,147	34,147
F	1794.664		98.842

Note. This table presents estimates from DHS data from Burundi in 2016-2017. The table has two different models: linear regression model with a continuous dependent variable (Ideal number of children) and LPM and probit model, a non-linear probability model with a dummy dependent variable (non-more children). LPM is estimated by OLS. We used heteroscedasticity-robust OLS standard errors for confidence interval and hypothesis testing. The stars indicate statistical significance where *,**, and *** respectively represent 10%, 5%, and 1% significance levels. The interpretation of the results is based on a 5% significance level. Heteroscedasticity- robust standard errors are given in parentheses under coefficients and the second parenthesis indicates t-values, which is also crucial when calculating the statistical significance of our coefficients.

In Table 7, we present the empirical results of three final models that are based on the household survey data. The models investigate the respondents' (women) fertility preferences given the factors of interest. Both linear probability and non-linear probability models show similar effects (sign of the coefficients) of the regressors on the dependent variables. There is no coefficient, for the LPM, that is not in the probability range; the estimates share the same qualitative features with the nonlinear model's. The results and coefficients of these models are all worth considering, but we pay particular attention to the variable showing similar and significant effects on the left-hand variables in all the 3 models. For example, the coefficient of the household head's education and its relation to the dependent variables are not consistent across models. So, we are not targeting variables of such a nature.

The probability of desiring more children is higher in women living in rural areas than those in urban. The same is true with the linear model, women in rural areas have a higher number of ideal children than those in urban areas; the coefficients are statistically significant. Non-educated women, those who did not go to school or manage to finish primary school, are 13% more likely to demonstrate a desire for more children, on average, everything else remains constant than those who at least finished primary education. In the linear model, those same women, non-educated, have a 10% higher number of ideal children than the other group. In both models, those who identify as catholic are less likely to want more children and have fewer ideal children than others in other religions. Finally, respondents who are at least from middle-income families grouped as "wealthy" according to the DHS wealth index standard, have a higher probability of preferring more children and a greater number of ideal children than those in low-income categories in all the models.

VII. Results Discussion and Policy

Burundi's population growth presents a significant obstacle to economic growth and development, both in the short and long term. This demographic surge adversely affects both real income per capita and cereal production per capita, thereby undermining living standards. Since 1972, the population of Burundi has more than tripled from 3.6 million people, and without intervention, it is projected to double within the next 26 years, reaching approximately 25 million people by 2050. With arable land likely to remain constant, this rapid population increase would result in arable land per capita shrinking to less than 0.05 hectares (500 square meters).

It's worth providing context on the short-term and long-term implications of the series analysis results. High fertility rates can notably reduce women's productivity, particularly in agriculture, in the short term, contributing to the negative effects of population growth on economic development. In Burundi, where a larger proportion of women are engaged in rural, hand-crafted agriculture compared to men, societal norms often prioritize women's roles in childbearing, caregiving, and domestic duties. Consequently, women may struggle to balance these responsibilities with farm work, incentivizing larger family sizes to bolster labor supply. Pregnant women and mothers with young children may experience diminished productivity in agriculture, leading to reduced income and food production, especially on a per capita basis. The influx of additional children into the population exacerbates resource strain in the short term, as a significant portion of household income is diverted towards meeting their needs until they enter the labor force. This translates into lower savings rates and limited investments in both physical and human capital, hindering technological advancements and innovation across sectors. Consequently, Burundi's stagnant economic growth underscores the negative correlation between population growth and real income per capita.

Looking ahead, the long-term ramifications of sustained population growth in Burundi include land scarcity, leading to diminishing returns in agriculture amidst minimal technological progress. Additionally, the youth-dependent ratio, exacerbated by high levels of youth unemployment and educational pursuits, poses challenges for the future workforce. According to the 2022 UNICEF report, nearly half of young adults aged 15 to 24 are considered "inactive," further straining the economy. Thus, high birth rates not only impact short-term economic dynamics but also pose long-term challenges, particularly when these children reach working age but encounter difficulties securing employment opportunities.

Creating those jobs hinges on increasing economic activities in the country. Increased economic activities, including domestic and international trade, and free markets will lead to increased revenue through the stimulation of supply and demand and the ability to adapt to market flux.

Nevertheless, those economic activities will not be sustainable or competitive if the majority of people still face food scarcity. Multiple factors of production such as diminishing (quality of) land supply, low investment in the food production industry, and low demand in the agriculture-based food industry, due to a high proportion of people relying on subsistence farming for their consumption, exacerbate the low food production. As food shortages persist in tandem with population growth, food expenses for individuals surge, which constrains their ability to save and invest in other areas of the economy. The negative relationship between per capita food production growth and population growth echoes Thomas Malthus' theory of population growth increasing geometrically, while food production increases only arithmetically, resulting in food scarcity and starvation. Malthus's prediction did not occur in England because of technological advancement, which came to offset the impact of population growth. It is possible that Burundi can also escape this Malthusian trap through technological advancement and more capital in the farming industry, which would increase the food supply and stimulate economic growth. However, this technological advancement and capital accumulation does not happen overnight. As Yin (2012) points out, it is a process of capital accumulation, that eventually leads to structural transformation.

Efforts aimed at addressing Burundi's challenges with diminishing food production and resource depletion should not overlook the relevance of both classical and neoclassical growth theories. To transform the country from a subsistence economy to an industrialized and commercialized one does require a strong physical, financial, and human capital accumulation at all levels of the society, which will eventually spur technological advancement. So, it is due to the limitations of capital accumulation that production does not get viable, resulting in resource scarcity and diminishing returns in agriculture that the country is facing. Therefore, avoiding this diminishing return in agriculture would require a substantial investment in the industry. However, agriculture in Burundi faces numerous constraints, including climate change, persistent soil infertility, diminishing availability of arable land, and predominantly mountainous terrain unsuitable for mechanization and prone to flooding during heavy rainfall. Based on the findings from both descriptive and empirical analyses, we strongly recommend that the government of Burundi adopt and implement policies aimed at facilitating agricultural reform, promoting trade and competitive markets through privatization, promoting good institutional quality, and implementing population control measures concurrently.

1. *Farming reform*

Agriculture and livestock reform will require Burundian farmers to go beyond subsistence levels. For that to happen, farming expansion, extension, and specialization are critical. Both farming extension and expansion will necessitate enough arable land supply for the farmers to produce in large quantities. The extension will happen through an increase in farmers' know-how, done hand in hand with rural road construction and electricity supply (Gebresiasse, 2023). Those skilled farmers with enough land will increase their productivity through specialization, which will require farmers to farm what they have a competitive advantage in and trade with others (see Ricardian classical trade model)[22]. Agricultural and livestock sectors will gradually shift from labor-intensive to capital-intensive, resulting in fewer jobs in this sector as people find other opportunities elsewhere. Multiple obstacles, however, stand in the way of this reform. Unless the government has enough funds to build enough rural roads and provide enough electricity, specialization, and extension may not be successful. Land supply to farmers is another major

[22] The classical ricardian trade model highlight the importance of specialization and trade between states. The suggests that, to be better off, each country should produce what they have a competitive advantage in and trade amongst each other. This specialization and trade can also happen domestically amongst producers who want to maximize their profits.

challenge, especially flat land, as well as the rising farming costs resulting from climate change, land overexploitation, and degradation. These obstacles, which have not been properly addressed, have significantly contributed to a declining productivity per farmer over time. This low production has prevented a structural transformation of the economy that could have generated higher and stable levels of economic growth(Nkurunziza et al., 2012). Rapid population growth exacerbates the problem of land overexploitation, as the supply of arable land declines. Without a significant reduction in population growth and increased government investment in infrastructure, agriculture, and livestock reform, achieving meaningful progress beyond subsistence farming will remain elusive.

2. *Privatization to promote a competitive market.*

To avoid Burundi falling into the old-structuralism trap, which resulted in market failure (Lin, 2012), private sector development is paramount to the economic growth of the nation. To promote business innovation, human capital development, and job creation, the government is responsible for promoting privatization through domestic and foreign investments. Ensuring peace and security and investing in human and physical capital are among the government's responsibilities in addition to creating a safe, efficient, and corruption-free institutional space. Lin's (2012) new structuralism adds that the government's contribution such as creating a space for fostering businesses' growth opportunities, low investment risks and high profitability is a key to growth. If a country is attractive enough to investors, which means they can work freely and can make the profits they are looking for, both domestic and foreign capital mount. Burundi should be a very attractive nation for investments, given the country's cheap labor endowment. However, capital and investments, important factors of growth in both classical and neoclassical theories, have not been growing to keep up with the population. The stagnant growth of capital and technology has kept the country in a low capital-per-labor trap, resulting in a perpetual subsistence economy due to diminishing marginal returns per labor. It is through policy implementation that the government of Burundi can promote growth in income per capita, and supply and demand on the market.

3. *Population control*

Keeping population growth under control will boost all other economic development plans in Burundi. With most of the Burundi population relying on agriculture, practiced mostly on sloppy and erosion-prone land, growing populations are exacerbating land scarcity and climate change effects. It would require a considerably high investment in technology to offset the impact of population growth. In other words, as populations grow, the technology required to maintain output is more expensive and requires more investment and labor (Jolly and Torrey, 1993). According to classical growth theories, the advancement of technology occurs through capital accumulation and savings, which happens on both individual and national levels. Without population control, it would take longer to accumulate that capital, and human capital to stimulate economic growth. While more than 90% of the population is still relying on subsistence farming, markets are still unreliable and not diversified, which increases investment risks and prevents capital inflows. Without domestic and foreign investment, the needed level of imports and exports that are critical to income per capita growth is still harder to achieve. It is through population control that farming, and business development can develop thanks to an increase in capital and supply and demand on the market. To achieve structural transformation, a policy to curb the rapid demographic burgeon, beyond family planning social campaigns that have been around for decades, is crucial. According to the 2019 World Bank report, Burundi's high fertility limits girls' education, and hence their workforce participation, leaving most women in informal jobs that are low productivity, low wage, and low skilled. Women, whose proportion is 50.4%, are the backbone of Burundian economic development; lower fertility will bolster their productivity and mobility, which will facilitate their full participation in the extension programs. Women will be more productive and skilled, leading to a significant improvement in agriculture, which is predominantly female-dominated.

As it was done in China[23] and other low-income countries in the 1950s like Singapore[24], population control would not only improve agriculture production but also will lead to an increase in skilled labor. This will spur innovations, investments, and people's desire to pursue their economic goals. Burundi does not need to adopt a policy akin to China's One Child Policy, as this could result in long-term population decline and labor shortages. However, analysis of DHS data reveals that a significant proportion of respondents, including those with more than 8 children, are amenable to having between 3 and 4 children. The study suggests that a maximum of 3 children per woman could foster economic development by enhancing marginal returns and supplying a skilled labor force. Additionally, such a policy would safeguard maternal health, enabling women to pursue professional and economic aspirations.

VIII. Conclusion

[23] Prior to the Green Revolution, China's agricultural growth was slow. Despite emphasis on self-sufficiency, the population grew faster than grain production and agricultural output. The economy faced severe shortage of capital, natural resources, and consumer good (Wang et al. 2016). Agricultural output increased by over 61% between 1978 and 1984 (Arendonk, 2015). This was mostly the results of one child policy effective since 1979 and lots of other population control measures prior to that. China's economic boom over the last few decades has lifted hundreds of millions out of poverty, sent almost 100 million young men and women to college, and inspired generations of Chinese, both young and old, to pursue their economic goals (Wang et al. 2016)

[24] See: SWEE-HOCK, S. (1980). The Development of Population Control in Singapore. *Contemporary Southeast Asia*, *1*(4), 348–366. http://www.jstor.org/stable/25797589

This paper uses both empirical and theoretical analysis to study the impact of high demographic growth on economic development, paying particular attention to both classical and neoclassical economic growth theories. We find a robust negative relationship between population growth and both real income per capita and cereal production per capita in the short and long run. Using the DHS data, we find a significant desire of Burundians to lower their birth rates down to 3 or 4 children per woman. This is a hint that efforts to lower the fertility rate in Burundi to 3 children max through the implementation of different measures such as improved widespread family planning and birth incentives and disincentives should be adopted. It is still possible to boost the country's economy by pursuing structural adjustment goals that will stabilize food security and create a growing marginal return per labor and capital. The government's role in promoting population control, agriculture reform, and market privatization is irreplaceable in reversing the country's economic trend.

Our analysis demonstrates that Burundi has fallen into a subsistence economy trap, where solely focusing on agricultural reform proves impractical due to constraints such as limited farmers' capital and land availability. These limitations hinder technological advancements and innovation across other sectors. Furthermore, the country's low supply and demand dynamics pose significant challenges for achieving goals related to market privatization. Moreover, solely curtailing population growth, without complementary economic development initiatives, may not effectively bolster overall economic progress. To mitigate the adverse effects of resource depletion and diminishing returns, it is imperative to implement a multifaceted approach. This approach entails concurrently addressing demographic growth while undertaking reforms in the agriculture and livestock sectors. Additionally, fostering a conducive environment for business development and promoting a free and competitive market are vital components of sustainable economic development. By implementing these three strategies simultaneously, Burundians will be better positioned to attain their economic objectives, thereby fostering stability in the country's economy at both the individual and national levels.

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Appendix

ST 1. Summary Table of all variables used in Model 3&4

Variable	Obs	Mean	Std. dev.	Min	Max
xmore_child	34,147	.6270829	.4835874	0	1
ideal_chil~m	34,147	4.185111	1.639731	0	15
p_yrseduc	34,147	3.236009	3.84949	0	18
t_children	34,147	5.794623	2.520557	1	15
rural	34,147	.8546871	.3524212	0	1
age_respo	34,147	36.14312	7.38844	17	49
catholic	34,147	.562597	.4960734	0	1
xeduc	34,147	.5566228	.4967908	0	1
wealthy	34,147	.6110932	.4875092	0	1

Note. This table shows a summary statistic of the variables used in the model (Models 3 and 4). The model has 34,147 observations. Each observation represents a household, which is in return represented by one responder per household. The whole data set's observation is around 51,000, but because we are interested in recording women's responses in this study, maintaining women respondents dropped the initial observation down to 34, 147. The respondents are between 17 and 49 years old, among which 64% are less than 40 and 36% are more than 39 years old. Among all women who responded to the survey, 62% of them don't want more children, 85% live in rural areas, 56%

are catholic, 61% are wealthy, and 55% are not educated. The average ideal number of children is 4, and the average total number of children is around 6 children per woman.

ST 2. Fertility preference based on age group.

```
. sum ideal_chilnum t_children xmore_child if age_respo>=40

    Variable |        Obs        Mean    Std. dev.       Min        Max
-------------+---------------------------------------------------------
ideal_chil~m |     12,360    4.204935    1.744314          0         15
  t_children |     12,360    7.644498    2.172285          1         15
 xmore_child |     12,360    .8366505    .3696992          0          1

. sum ideal_chilnum t_children xmore_child if age_respo<40

    Variable |        Obs        Mean    Std. dev.       Min        Max
-------------+---------------------------------------------------------
ideal_chil~m |     21,787    4.173865     1.57725          0         15
  t_children |     21,787    4.745169    2.058597          1         12
 xmore_child |     21,787     .508193    .4999443          0          1
```

Note. For respondents with ages above 39, having 4 children is perfect on average, 84% of them don't want more children. All the respondents within this age group have 8 children on average. Among the group of respondents whose age is less than 40, they also think 4 children is an ideal number; 51% of them say they don't want more children and the average of total children ever born in that group is 5 children per woman.

ST3: Fertility Preference table based on age group

```
tab ideal_chilnum if age_respo>=40

   ideal number of |
          children |      Freq.     Percent        Cum.
-------------------+-----------------------------------
                 0 |        153        1.24        1.24
                 1 |         70        0.57        1.80
                 2 |        752        6.08        7.89
                 3 |      3,661       29.62       37.51
                 4 |      3,709       30.01       67.52
                 5 |      1,961       15.87       83.38
                 6 |      1,094        8.85       92.23
                 7 |        285        2.31       94.54
                 8 |        294        2.38       96.92
                 9 |         63        0.51       97.43
                10 |        266        2.15       99.58
                11 |         11        0.09       99.67
                12 |         33        0.27       99.94
                15 |          8        0.06      100.00
-------------------+-----------------------------------
             Total |     12,360      100.00
```

Note. 90% of the respondents with more than 39 years think it is perfect to have 2 to 6 children, with 30% of the respondent's ideal number being 4

ST 4: Fertility Preference table based on age group

```
tab ideal_chilnum if age_respo<40
```

ideal number of children	Freq.	Percent	Cum.
0	261	1.20	1.20
1	179	0.82	2.02
2	1,159	5.32	7.34
3	6,010	27.59	34.92
4	6,749	30.98	65.90
5	4,038	18.53	84.44
6	2,197	10.08	94.52
7	385	1.77	96.29
8	406	1.86	98.15
9	36	0.17	98.32
10	319	1.46	99.78
11	7	0.03	99.81
12	36	0.17	99.98
15	5	0.02	100.00
Total	21,787	100.00	

Note. 87% of the respondents with less than 40 years of age have the ideal number of children preferences between 3 and 6 while 7.3% prefer less than 3 and 5.7% more than 6.

ST 5:Number of children tabulation based on age category

```
tab t_children if age_respo>=40
```

total children ever born	Freq.	Percent	Cum.
1	28	0.23	0.23
2	116	0.94	1.17
3	249	2.01	3.18
4	528	4.27	7.45
5	1,005	8.13	15.58
6	1,644	13.30	28.88
7	2,156	17.44	46.33
8	2,416	19.55	65.87
9	1,872	15.15	81.02
10	1,270	10.28	91.29
11	594	4.81	96.10
12	348	2.82	98.92
13	91	0.74	99.65
14	28	0.23	99.88
15	15	0.12	100.00
Total	12,360	100.00	

Note. 84 % of the respondents above the age of 39 have given birth to 5 to 10 children. Only 7% less than 5 children and 9% more than 10 children.

ST 6: Number of children tabulation based on age category

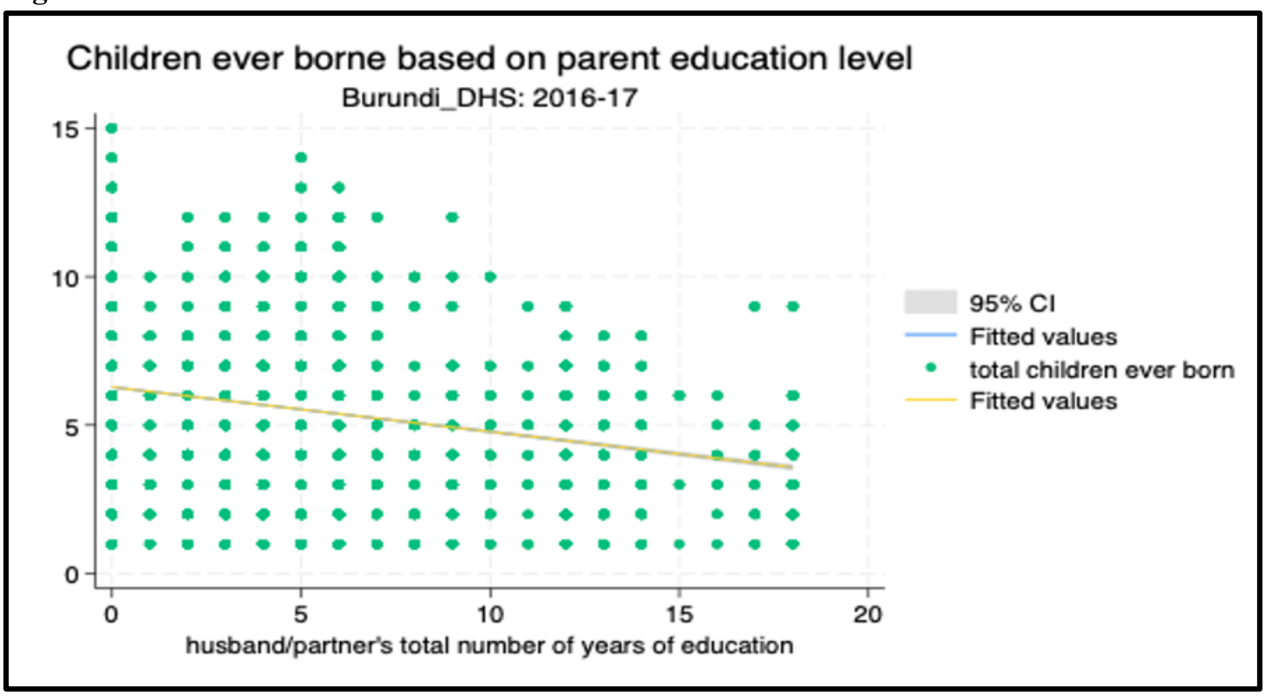
```
tab t_children if age_respo<40
```

total children ever born	Freq.	Percent	Cum.
1	886	4.07	4.07
2	2,264	10.39	14.46
3	3,426	15.72	30.18
4	3,784	17.37	47.55
5	3,730	17.12	64.67
6	3,336	15.31	79.98
7	2,303	10.57	90.55
8	1,248	5.73	96.28
9	513	2.35	98.64
10	160	0.73	99.37
11	77	0.35	99.72
12	60	0.28	100.00
Total	21,787	100.00	

Note. 91% of the respondents with less than 40 years old have given birth to between 1 and 7 children, and only 9% have more than 7 children.

Graphs

Figure A1.



These two figures are scatter plots showing the relationship between population growth and both cereal production per capita and real income per capita from 1972 to 2022. We see a negative correlation between those variables.

Figure A2

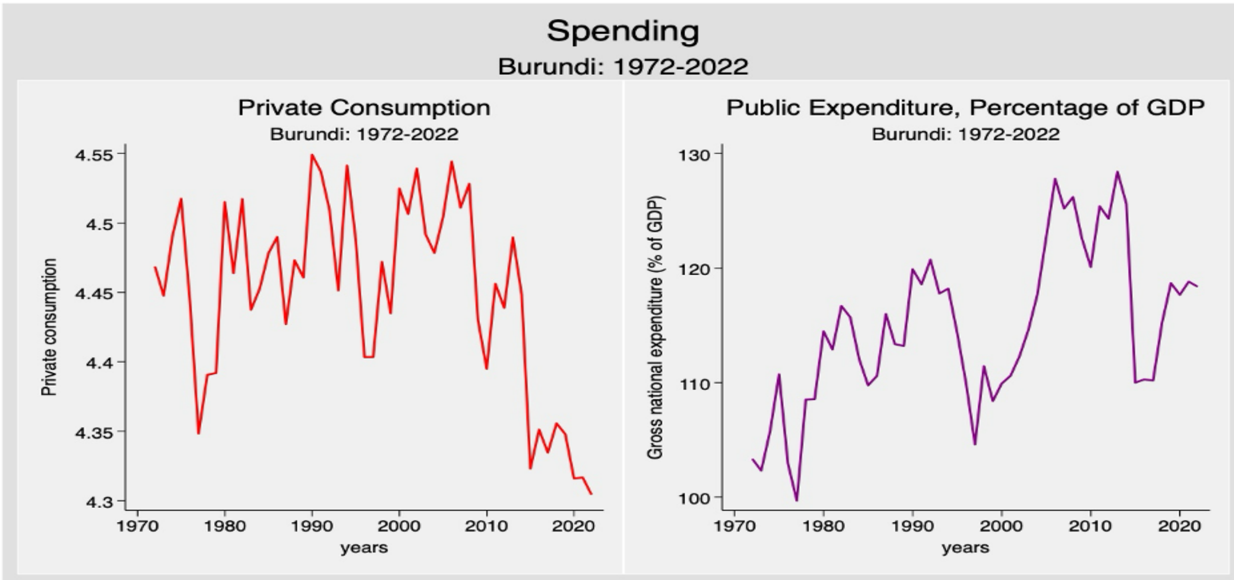
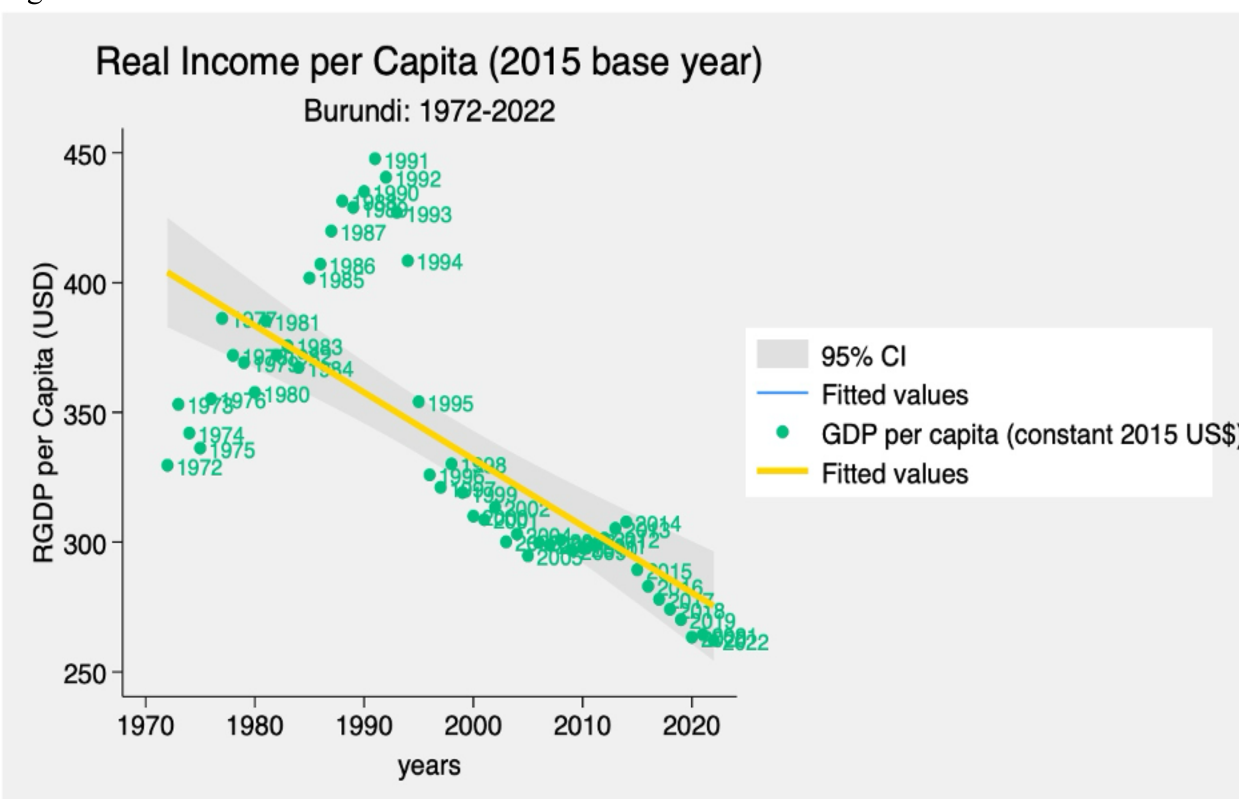
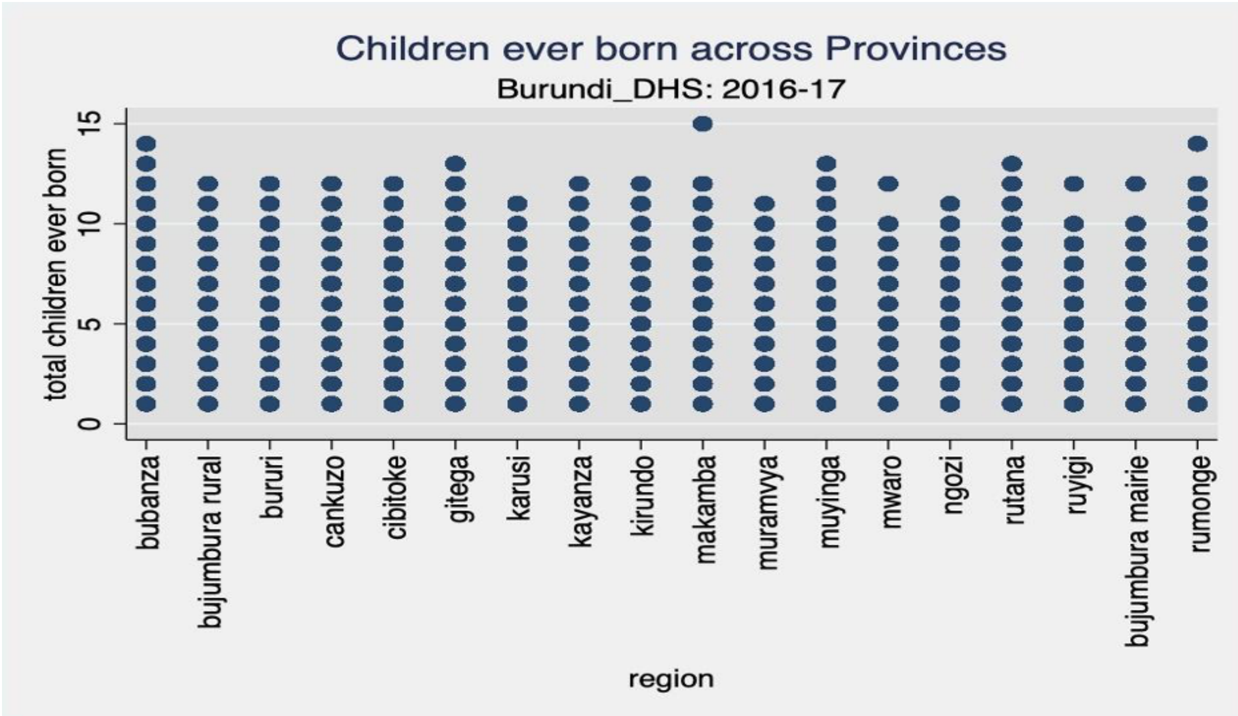


Figure A3



Note. Real GDP per capita in Burundi: GAGR since 1972 =- 0.45%; and CAGR of -1.6% since 1990

Figure A4



Note. DHS household data: 2016-17; children ever born across provinces of Burundi. Each dot represents a cluster of households with the same number of children within the same province.

Figure A5

Note. Burundi map. Source: Nations Online Project