



The Economic Consequences of Population Growth in Malawi

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Abstract

There is a vast amount of theoretical and empirical literature attempting to establish the impact of population growth on economic growth. Despite the immense amount of research on the topic, there is still no consensus. Malawi presents an interesting case to investigate this issue as it is a small, low-income economy that is experiencing significant population growth. Furthermore, there is no previous economic analysis on the economic impact of population growth in Malawi. This paper, using the ARDL approach to cointegration with World Bank and International Monetary Fund data over the period 1960 to 2021 explores whether the increasing population is beneficial or detrimental to Malawi's economic development. The impacts of investment and total factor productivity on output are also assessed. The results show that increases in population are associated with decreases in GDP per capita in the short run. However, no statistically significant relationship between population and GDP per capita was established in the long run. Furthermore, results indicate that increases in investment are growth endorsing in the short run, while increases in total factor productivity promote growth in both the long run and short run.

Keywords: Malawi, Population Growth, GDP, Economic Growth, Economic Development, Investment, TFP, ARDL

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Section 1: Introduction

Malawi is a small, low-income economy that has been experiencing significant population growth over the past few decades. In 1960, the population was 3.7 million and in 2021 the population was 20.4 million (The World Bank, 2022). If Malawi's fertility remains constant, the population is expected to reach an estimated 33.6 million by 2050 (National Statistical Office, 2022). A key indicator of individual economic prosperity is the level of gross domestic product (GDP) per capita. In Malawi, GDP per capita increased from US\$45 in 1960 to US\$424 in 2021 which denotes an increase in average incomes. Regardless, approximately 50% of the population still live in poverty, basic services such as healthcare, education, and electricity are in short supply, and there are still high levels of unemployment (The World Bank, 2022). It is projected that these issues will only be exacerbated by the population growth (National Statistical Office, 2022).

The economic consequences of population growth have been investigated by numerous scholars over the past few centuries (West & Kishore, 2021). These intellectuals have used a range of models applied on an array of countries. These include: employing exogenous or endogenous models; studies that make use of panel, cross-sectional, or time-series data; analyses covering individual countries or a collection of countries (Demeny, 2011). Ultimately, the empirical evidence of the impact of population growth on economic advancement is still inconclusive, perhaps due to idiosyncratic factors of individual countries.

Unfortunately, there has not been any analysis on the economic consequences of population growth in Malawi. This may be because the existing studies related to population growth in Malawi are spread across numerous subjects, such as environmental change, family health, and poverty (Ricker-Gilbert, Jumbe, & Chamberlin, 2014). Nonetheless, it can be inferred from papers written in other countries and continents that population growth would likely have economic consequences. As Malawi is a developing economy, significant population growth could lead to low investment in human resources and infrastructure leading to lower standards of living and productivity (Page, 2019).

This paper investigates the impact of population growth on economic growth in Malawi over the period of 1960 to 2021. It also assesses the contribution of investment and total

factor productivity (TFP) towards GDP per capita. The study employs the Solow growth model. Additionally, the analysis is done using annual data from the World Bank over the period of 1960 to 2021. The available data series are examined using an Autoregressive Distributed Lag (ARDL) approach to cointegration which assists in identifying long-run trends in the presence of considerable short-run volatility.

The paper is divided into different sections. Section 2 discusses the theoretical and empirical literature on the economic impacts of population growth. Section 3 provides a descriptive overview of Malawi's population, GDP, investment and TFP trends to give better insight into the economic and social climate in Malawi. Section 4 specifies the model, data, and methodology employed in this paper. Then, Section 5 presents the empirical analysis and discusses the empirical findings. Finally, section 6 summarises the work focusing on the main conclusions and provides limitations as well as policy recommendations.

Section 2: Literature Review

The economic consequences of population growth have been analysed by various economists. A range of approaches were used in their work, for example focusing on a particular country whilst controlling for different policies and government structures or conversely conducting cross-country studies in which differences cannot be smoothly controlled (Demeny, 2011). Despite the numerous collections of work, the empirical evidence on the impact of population growth on economic development is still inconclusive (Das Gupta, Bongaarts, & Cleland, 2011). Additionally, there are some disputes on the channels through which population growth affects economic growth (Gale & Lee, 1987). Despite the analytical differences, there is a broad consensus that population size and structure play a vital role in facilitating or hindering economic development, and impact aspects such as poverty reduction, infrastructure investment, and income per capita (Demeny, 2011).

In 1798 Thomas Malthus presented one of the first theories related to population growth and its impacts on society (Weir, 1991). Malthus argued that population and resources maintain a homeostatic balance (Stangeland, 1904). This meant that, under suitable living conditions, the population will grow until it is restrained by either the "preventative check" of controlling reproduction, or by shortages in resources such as famine, disease, or war which result in "positive checks" (Das Gupta, Bongaarts, &

Cleland, 2011). Malthus' theory was based on the strong assumption that the supply of key factors of production, for instance land, were mainly fixed (Weir, 1991). This theory was plausible at the time Malthus wrote because economic historians and historical demographers show that GDP growth and real wages were stagnant or very sluggish over centuries and even over millennia (Kelley, 1988). For example, the GDP per capita in Europe between 500 and 1500 was zero, the real wage in England was roughly the same in 1800 as it had been in 1300, and real wages in China were the lower at the end of the eighteenth century than they had been at the beginning of the first century (Das Gupta, Bongaarts, & Cleland, 2011). Additionally, fertility control was present in the form of methods such as never-marrying, postponed marriage, infanticide and abstinence (Heijman, 1998).

However, more recent analyses revealed that the Malthusian model does not hold in modern day times because many things have changed since the time of Malthus' work (Peacock, 1952). The Malthusian model solely holds in early stages of development when output per capita is roughly stationary and any episodes of technological change lead to proportional increases in output and population (Weil & Wilde, 2009). For example in Ireland, where advances in potato farming allowed a great increase in population over the century before the Great Famine, unfortunately without an improvement in living standards (Das Gupta, Bongaarts, & Cleland, 2011). Additionally, the function of "preventative checks" has been disturbed by technological advances that are now available even in low-income areas (Weir, 1991). Moreover, advances in industrial and agricultural technologies have made way for changes in productive capacity in society that enables the sustenance of growing populations, thus ushering in the need for newer models (Bakare, 2011).

The 1900s gave rise to three influential exogenous models, namely the Harrod-Domar, Coale and Hoover, and Solow models. Ultimately these models indicated that population growth constrains economic development. The first model is the Harrod-Domar model which explains the relationship between population growth and an economy's growth rate through the levels of capital and savings (Heijman, 1998). In the most basic case, the model states that the growth rate of GDP is equal to the average propensity to save divided by the incremental output to capital ratio (Eltis, 1987). A population growth rate of zero would result in a GDP per capita growth rate which is equal to the average propensity to save divided by the incremental output to

capital ratio (West & Kishore, 2021). This is because the growth rate of GDP per capita is equal to the growth rate of GDP minus the growth rate of the population (Das Gupta, Bongaarts, & Cleland, 2011). Thus, every 1% increase in the population growth rate translates into a 1% fall in the growth rate of per capita GDP (Hochestien, 2017). Overall, their model showed that, in the absence of diminishing returns to capital, growth in income per capita is negatively affected by population growth and positively affected by savings and increases in the output to capital ratio (Das Gupta, Bongaarts, & Cleland, 2011).

Empirically, Klasen & Lawson (2007) used the Harrod-Domar approach to examine the link between population, per capita economic growth, and poverty in Uganda. Their analysis suggested that high population growth puts a considerable break on per capita growth prospects in Uganda. In addition, they concluded that high population growth contributes significantly to low achievement in poverty reduction and is associated with households being persistently poor or moving into poverty, therefore limiting the country's development prospects. Similarly, the results of Bakare (2011) supported the Harrod-Domar model and concluded that the growth rate of national income is directly or positively related to the saving ratio and capital formation in Nigeria, thus any growth in population that alters these variables would feasibly result in changes in economic growth. Conversely, West & Kishore (2021) who analysed the capability of the Harrod-Domar model to explain economic outcomes in Guatemala and Libya found that the model is a good representation of growth for both countries, but only when considering the savings ratio (Gross Capital Formation), the capital output ratio and not when analysing population growth. Additionally, they determined that following the Harrod-Domar framework alone is not sufficient to address the changes needed to help people out of low-income levels. This indicates that it may be flawed when attempting to solve problems in economically developing nations and endorses the need for more suitable analysis methods.

The swing away from the use of the Harrod-Domar model could be due to some of its other shortfalls. One criticism of the model is the severity of some of its assumptions, which Domar himself later detailed were unreasonable, causing an oversimplification of complex factors that influence economic development (Easterly, 1997). These include: price-level is fixed which implies that the relative price of capital and labour is fixed; capital and labour are used in equal proportions in the economy; savings rates

and marginal returns to capital are constant; and an economy's productive capacity is proportional to capital stock (Sato, 1964). Another criticism is that it streamlines economic development to economic growth, however holistic development involves benefits from this growth, for instance through, poverty reduction, improved healthcare, and upgraded education (Gale & Lee, 1987). Finally, the model is criticised for its inability to include some characteristics that hinder the progression of developing countries (Das Gupta, Bongaarts, & Cleland, 2011). These nations frequently have low marginal propensities to save because of widespread poverty, high levels of corruption, high debt levels, and unreliable finance and transport systems (West & Kishore, 2021). This may be because Harrod based his model on industrialised countries post-depression years, thus disabling the explanation of economic development for nations in other economic climates (Eltis, 1987).

The second influential growth model is the Coale and Hoover model which was developed by focusing its analysis of the relationship between population growth and economic growth solely on India in the 1950s (Coale & Hoover, 1958). At the time, India had low income levels, low industrialization, low GDP growth, and relied heavily on subsistence agriculture (Bhat, 1996). Coale and Hoover concluded that population growth can constrain economic growth through both population's increasing size and structure (Coale & Hoover, 1958). The combined effect of the two factors divert national resources away from investment in expanding productive capacity and increasing the capital to labour ratio to cater for the growing population's other infrastructure needs such as housing, schools, and health (Das Gupta, Bongaarts, & Cleland, 2011). Additionally, at the household level, individuals divert resources away from saving and productive investment towards current consumption needs (Bhat, 1996). Ultimately, rapid population growth would result in decreases in infrastructure investment, a key variable for economic development.

Studies which used a wide range of macroeconomic and microeconomic analytical methods, including updated approaches to cross-country regressions, affirmed different aspects of the Coale and Hoover model. For instance, Acemoglu and Johnson (2007) examined data from 47 countries from 1940 to 2000 and concluded that rapid population growth decreased income per capita, thus hampering economic development. In other papers, Coale and Hoover's youth dependency hypothesis, which declares that if a population has a high proportion of children relative to working

adults then the prospects for economic growth are diminished, received the most attention (Coale & Hoover, 1958). These high ratios are common in populations with high fertility, unfortunately a characteristic of many low-income countries who are striving for economic development (Kelley, *Economic Consequences of Population Change in the Third World*, 1988). Higgins & Williamson (1997) confirmed Coale and Hoover's ideas by concluding that high youth dependency ratios are indeed associated with lower savings and investment after analysing countries in Asia. Higgins and Williamson (1997) discovered that the considerable rise in Asian savings rates since the 1960s can be attributed to the substantial decline in youth dependency burdens. This effect was stronger in East Asian nations in comparison to South Asian nations as the fertility transition was swifter in the former. As a result of the higher savings rates, these Asian countries relinquished their reliance on foreign capital, another potential constraint to economic progression. Similarly, Kelley & Schmidt (2005) found that both youth and old-age dependency ratios accounted for 20% of per capita output growth impacts and had an impact on savings after analysing 65 developing countries and 23 developed countries over time and cross-sectionally since 1960.

However, the Hoover and Coale model presented some challenges. Firstly, it did not display any correlation between population growth rates and economic growth across a sample of developing countries (Kelley, 1988). Secondly, their argument that national resources would be redirected towards infrastructure needs did not hold up (Acemoglu & Johnson, 2007). For example, when analysing the education sectors across low-income countries with rising populations, higher enrolment rates and schooling completed rose significantly but this did not have any influence on the share of GDP allocated to the education sector (Das Gupta, Bongaarts, & Cleland, 2011). Instead, the cost per pupil decreased, class size per teacher increased, and teacher salaries fell (Das Gupta, Bongaarts, & Cleland, 2011). This implied that despite the increase in quantity of schooling demanded, no resources were diverted to this sector, which could reduce the quality of schooling. Thirdly, empirical studies could not confirm that high youth dependency ratios negatively affect savings, ultimately hampering economic growth. However, this was criticised by Kelley (1988), arguing that these studies may have methodological limitations such as variable specification issues and poor cross-country analysis that may have blemished the validity of the findings.

The third influential growth model is the Solow growth model which demonstrated that an exogenous increase in the population growth rate, under the assumption that both labour and capital experience diminishing returns, would lead to an increase in labour supply that would outpace the growth of capital formation, subsequently decreasing the income per capita (Solow, 1994). Another extension of the Solow model includes land and this can be used to analyse the impact of population growth on economic development in conjunction with how important agriculture is within the nation (Karras, 2010). This is beneficial when analysing countries like Malawi where a large proportion of economic output is from the agricultural sector (Ricker-Gilbert, Jumbe, & Chamberlin, 2014). In this case, the Solow model predicts that the effect of population growth on the growth rate of income per capita decreases with the importance of agriculture in the economy (McNicoll, 1984).

Empirical studies that employ the Solow model to analyse the consequences of population growth predominantly prove the theoretical expectations which show that population growth results in lower income per capita. Yao, Kinugasa, & Hamori (2013) found that population has a significantly negative impact on GDP per capita in China, therefore reducing standards of living. Similarly, Karabona & Koutun (2013) showed that population growth decreased economic growth and reduced the resources allocated to enhancements in human capital. Additionally, after analysing 152 countries using the Solow model with land, Karras (2010) found that the effect of population growth on the growth rate of income per capita varies across countries and is decreasing in the country's share of agriculture, which is consistent with the theoretical prediction of the Solow model.

The Solow model possesses some difficulties. The absence of an investment function in the model prevents the inclusion of a key element of economic development (Karabona & Koutun, 2013). Additionally, there are some unrealistic assumptions such as: the presence homogeneous labour and capital, flexibility of factor prices, and labour-augmenting technical progress, which may not retain sound empirical justification (Sato, 1964). Finally, it treats the causes of technical progress as exogenous factors in the growth process, thus leaving out some of the problems of inducing technical progress through the process of learning, investment in research, and capital accumulation (Weil & Wilde, 2009).

Despite the shortfalls, the Solow model is generally described as an improvement over other models when analysing the process of long-run development as some assumptions, like that of substitutability between labour and capital, give the growth process adjustability and provides a touch of realism (Gale & Lee, 1987). Furthermore the ability to include elements such as agriculture and rapidly changing population growth rates allows the analysis of an array of countries (Demeny, 2011). Thus, the Solow model can more precisely ascertain the economic consequences of population growth.

Recent years gave rise to endogenous population growth models. For instance, in Romer's (1990) theory of endogenous technological change, the non-rival nature of knowledge and ideas introduces economies of scale, which results in the growth rate of market output per worker varying with the population. An increase in the absolute size of the population raises the per capita growth rate, implying that large populations have more rapid increases in per capita income (Heintz & Folbre, 2019). However, other endogenous growth models present opposing views on the economic consequences of population growth. For example, Jones (1995) proposes a model in which changes in the size of the population affect the level of market income per capita, but not its growth rate. Therefore, this suggests that the growth of income per capita is positively correlated with the population growth rate (Heintz & Folbre, 2019).

Some growth models go further and endogenise population dynamics. Barro and Becker (1989) put forward an influential effort to include fertility decisions in a neoclassical growth model across an inestimable time horizon. Similarly, Galor & Weil (1996) offer a growth model with endogenous fertility based on over-lapping generations instead of dynastic utility maximization. In both models, an individual's fertility choices are informed by the maximisation of that individual's unitary utility function (Heintz & Folbre, 2019). In addition, other endogenous growth models incorporate bargaining dynamics. In these approaches, women's bargaining power is either exogenously given or related to the returns to their productive attributes in the paid labour market (Doepke & Tertilt). Thus, instead of a unitary utility function, women and men have different exogenous preferences and the models assume that women innately care more for their children in comparison to men (Agenor, 2017). Overall, the general conclusion from these models is that either negative or positive population

growth could stagnate the growth of per capita income depending on a country's productive characteristics (Heintz & Folbre, 2019).

However, endogenous models have some drawbacks. Firstly, some of the assumptions oversimplify reality (Agenor, 2017). They assume that households are identical and representative and that all women participate in childbearing and have the same fertility rate (Romer, 1990). The models also assume that, if households have children, the minimum number of children is equal to the number of adults (Doepke & Tertilt). The combination of these assumptions then sets a lower bound of zero population growth. Secondly, in their emphasis on individual utility optimization, many of these models ignore the possibility that individuals may engage in collective action with others to establish social institutions and public policies that affect intergenerational and inter-gender transfers of time and money (Heintz & Folbre, 2019). Thirdly, the abundance of variables and calculations may lead to data analysis issues when analysing many developing countries who often have data access and accuracy issues (Klasen & Lawson, 2007).

More recent adaptations of endogenous models have allowed for endogenous fertility and variations in returns to scale, linking macroeconomic dynamics with changes in the level and the distribution of the costs of reproduction (Heintz & Folbre, 2019). Moreover, they enable an approach to reproductive decision-making that goes beyond an individual's utility maximization and build on earlier overlapping generations' models by emphasizing the effect of non-market institutions which are shaped by the relative bargaining power of groups based on gender, age, citizenship, and other dimensions of a person's identity (Agenor, 2017). Additionally, these models allow for negative population growth as a long-run outcome which is a likely outcome in some developed nations (Doepke & Tertilt).

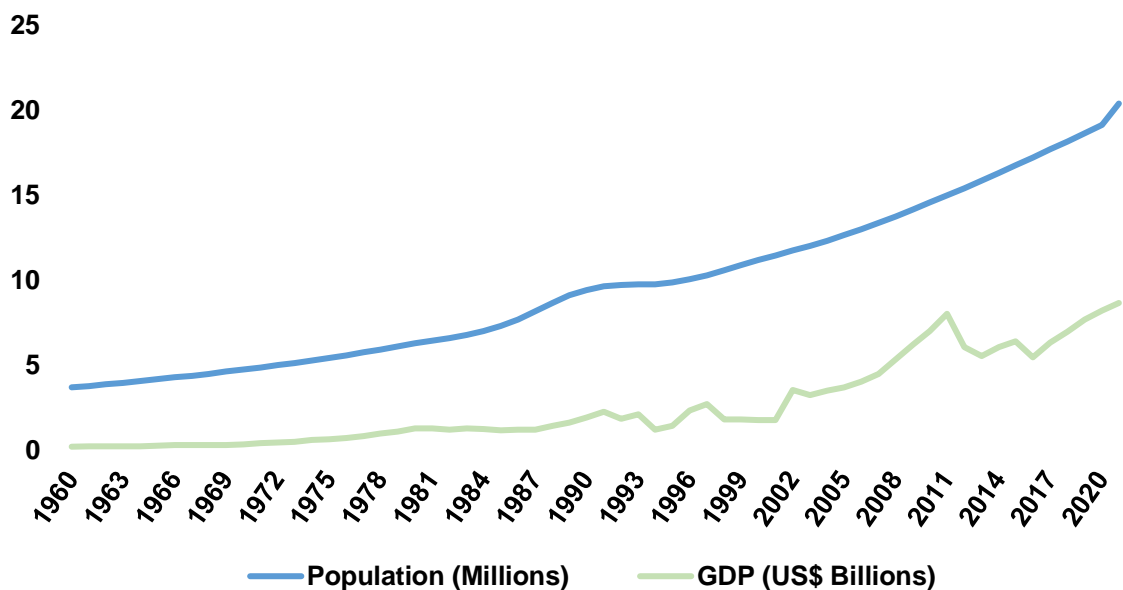
Although there have been papers studying the economic impacts of population growth, such as those discussed in this section, none have been centred on Malawi. This may be due to the *laissez-faire* attitude that Malawi has to population changes despite numerous warnings from international organisations of potential economic consequences (National Statistical Office, 2022). Despite the existence of comparable papers from other nations, it is not sufficient to apply what has been established in different economies to Malawi because it likely possesses dissimilar characteristics

such as employment, average income, and access to healthcare, education, clean water, and electricity (Folawewo & Adeboje, 2017). Evidently, different economic conditions are likely to breed different results with regards to the impact of population growth on the economy. Expectantly, this paper can present more precise results which can endorse enhanced policy recommendations that improve public sector responses if need be.

Section 3: Overview

Malawi is experiencing population growth as a result of high fertility rates coupled with decreased mortality rates (Resources for the Awareness of Population Impacts on Development (RAPID), 2017). Figure 1 below shows Malawi’s population in millions and GDP in billions from 1960 to 2021. In 1960, the population was 3.7 million (The World Bank, 2022). Over the period, Malawi’s population steadily increased, with more rapid growth from the mid 1980’s to the early 1990’s. In 2022, the population is 20.2 million with a projection to reach 33.6 million in 2050 (National Statistical Office, 2022). Figure 1 also shows that GDP has increased gradually over the period, although not as smoothly as population. GDP increased exponentially from the early 2000s to 2011 where it peaked at US\$8 billion. In subsequent years the total GDP fell, but began to increase again in 2016, eventually peaking at US\$8.3 billion in 2021.

Figure 1: GDP and Population



Source: Author generated using World Bank data

The overall population is skewed toward young people, that is, individuals under age 20, who made up approximately 56% of the population in 2015 (RAPID, 2017). Because of the large number of young women who will soon enter their reproductive years, Malawi's population will continue to grow, perhaps more rapidly. According to RAPID (2017) the fertility rate in Malawi is decreasing but is still high. Malawi's total fertility rate, which measures the average number of children a woman will have over her lifetime, has decreased significantly over time. It fell from 6.7 children per woman in 1992 to 4.4 in 2020 (National Statistical Office, 2022). However, both women and men have consistently reported that their ideal family size is smaller than the national total fertility rate; often couples have more children than they want (Palamuleni, 2017). This can be attributed to the lack of awareness or access to contraceptive methods, especially in rural areas (Palamuleni, 2017). Consequently, fertility is considerably higher in rural areas, at 4.7 on average, in comparison to urban areas which has an average of 3.0 (National Statistical Office, 2022). In addition, adolescent fertility rates are also high. Amongst women of age 15 to 19, 29% are pregnant with their first child or are already mothers (Palamuleni, 2017).

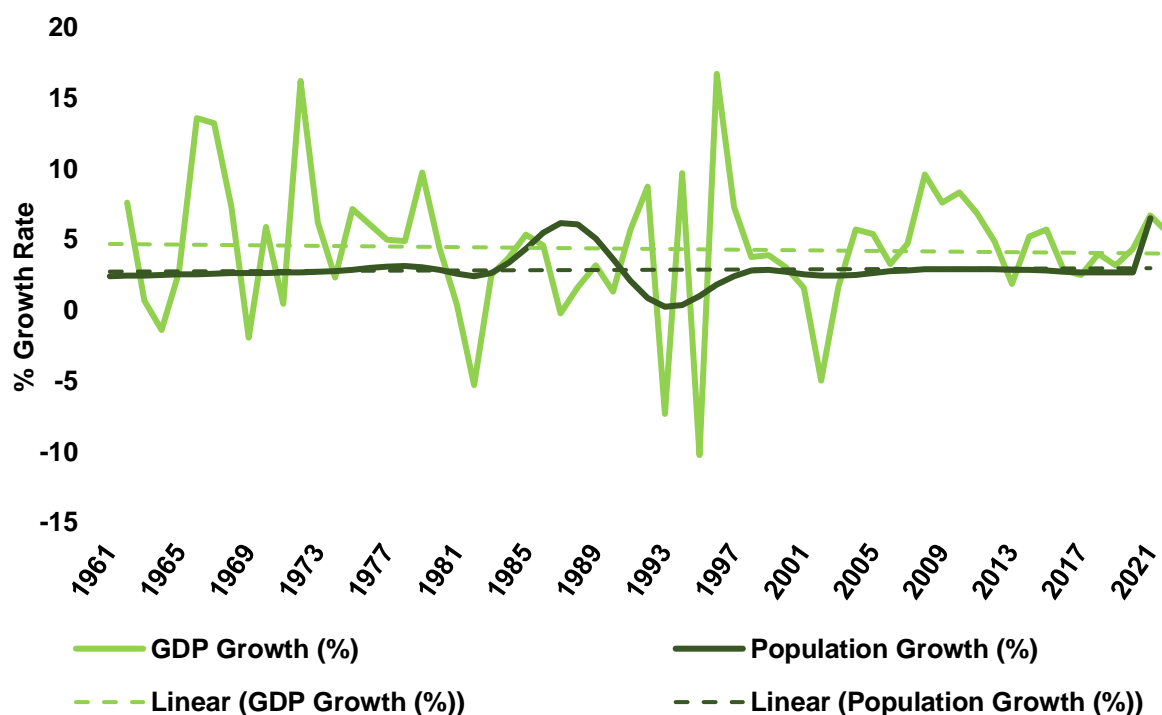
The country's future population will be influenced by current and future fertility rates as well as by the current age structure. Two fertility scenarios illustrate how fertility rates affect the size of the population. The first involves a constant fertility scenario which assumes that the total fertility rate remains constant at 4.4 children per woman. In this case the population is expected to grow to 42.8 million by 2050 which is more than double current population level (RAPID, 2017). The second involves a reduced fertility scenario. In this case, the total fertility rate decreases to 2.3 by 2050, thus the population is expected to grow to 34.3 million (RAPID, 2017).

In terms of GDP composition, Malawi is predominantly an agricultural nation with the agricultural sector accounting for one-third of GDP and about 80% of export revenue (Prowse & Grassin, 2020). The main agricultural products include tobacco, tea, sugarcane, coffee and maize (Page, 2019). Due to the presence of Lake Malawi, there is also a significant fishing industry (Tchereni, Sekhampu, & Ndovi, 2013). Malawi's manufacturing sector currently contributes about 10% of GDP, with activities such as food processing, construction, and cement production (National Statistical Office, 2022). However, this composition is concerning as Malawi is very vulnerable to climatic shocks, such as flooding and droughts, which severely impact agricultural

production and can explain the more variable output levels shown in Figure 1 (Tchereni, Sekhampu, & Ndovi, 2013).

Figure 2 below shows Malawi's real GDP or economic growth rate and population growth rate from 1960 to 2021. At the start of the period, economic growth was 7.6%. In 1963, GDP growth dipped to -1.4%. From then, the GDP growth rate fluctuated significantly over the entire period, potentially due to the predominantly agricultural nature of the economy. GDP growth peaked in 1971 at 16.2% and again in 1995 at 16.7%. Conversely, economic growth dipped to -7.3% in 1992 and reached its lowest point in 1994 at -10.24. This was likely due to the political unrest taking place in Malawi in the early 90s. This involved ending the 30 year rule of Hastings Kamuzu Banda of the Malawi Congress Party when Malawi was a single-party state in which political parties were illegal (Prowse & Grassin, 2020). After unrest in the early 90s, multiparty politics were legalised in 1994 (Page, 2019). The optimism from this victory could explain the spike in GDP growth in 1995. Similarly, a drop in GDP growth can be seen between 2008 and 2012 which likely reflects the impact of the Global Financial Crisis (GFC) on the Malawian economy (Tchereni, Sekhampu, & Ndovi, 2013). Since then GDP growth peaked at 6.7% in 2020, but dropped slightly in 2021 likely due to the effects of the COVID-19 pandemic restrictions on economic activity (National Statistical Office, 2022). Due to the high fluctuations in GDP growth rate, a linear trend is shown on the graph to provide further insight on the general movement of GDP growth. Unfortunately, the graph shows a slightly decreasing trend in the GDP growth rate over the period.

Figure 2: GDP & Population Growth (Annual %)



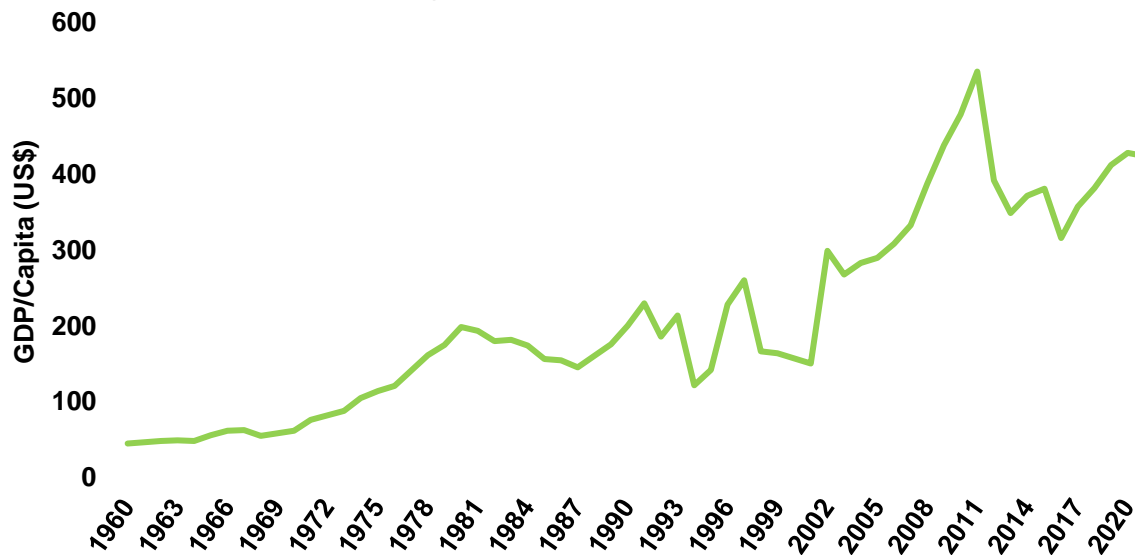
Source: Author generated using World Bank data

Unlike GDP growth rates, Figure 2 shows that the population growth rates are less variable. In the majority of the years, the population growth overlaps the linear trend. However, there is an increase in growth rate from the early 1980s, which then reaches a maximum of 6% in 1988. However this is followed by a rapid decrease which culminates in the slowest growth rate of 0.4% in 1994. Again this could be explained by the political unrest in Malawi at that period which could make some individuals wary about their reproductive decisions (Prowse & Grassin, 2020). Similarly, another rapid increase in population growth is observed in 2021. Nonetheless, the trend line shows a slightly increasing population growth rate.

To maintain or increase GDP per capita, the two variables must grow together or GDP must outgrow population respectively. However, from Figure 2, economic growth appears to have a slightly negative trend whilst population growth has a slightly positive trend. This is reflected in the enlarging gap between GDP and population in Figure 1. Figure 3 below shows Malawi's GDP per capita from 1960 to 2021. It can be seen that GDP per capita has an increasing trend which is a positive finding. The highest level of GDP per capita was US\$534.9 in 2011. However, there are many dips

in the curve, for example in 1994, 2001, 2013, and 2016, which may be a cause for concern. According to RAPID (2017) growing population will affect the degree to which Malawi can improve GDP and therefore GDP per capita. Under their reduced fertility scenario, GDP per capita is projected to be approximately US\$1,100 by 2050, compared to \$880 per capita if fertility remains constant.

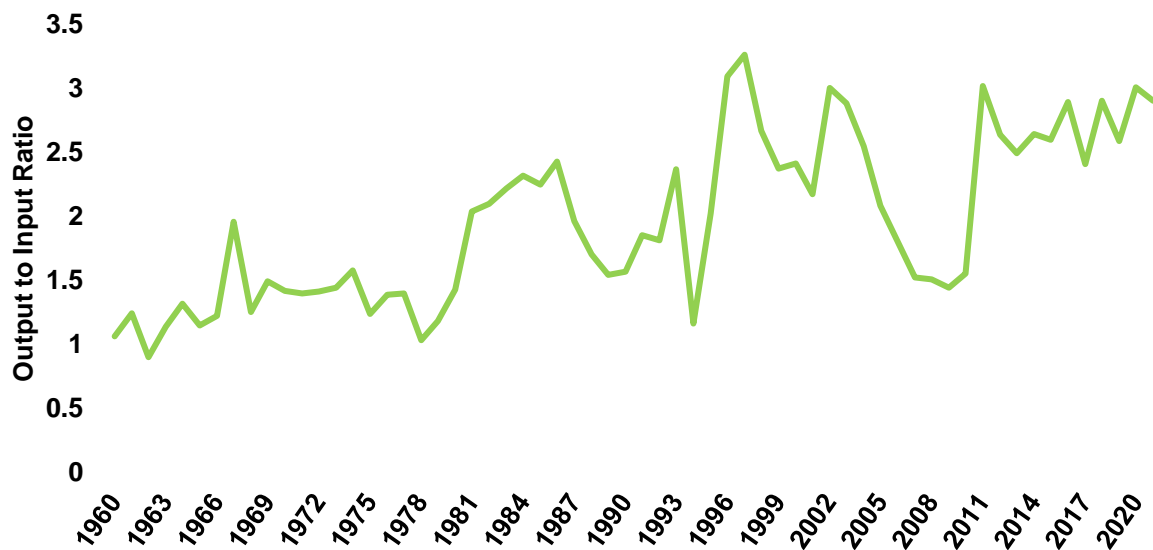
Figure 3: GDP Per Capita



Source: Author generated using World Bank data

Malawi’s economic prospects may also be affected by its total factor productivity (TFP) levels. This refers to the average ratio of output to input in the production process (Bakare, 2011). Increases in TFP shows that there is higher output per input, thus it should result in increases in output. Figure 4 below shows Malawi’s TFP which shows an increasing trend similar to that of GDP. The highest level of TFP was recorded in 1997 at 3.2. Nonetheless, there were rapid decreases in 1994 and the late 2000s. However, RAPID (2017) elaborates on the impact of population growth on aspects such as land availability, electricity, employment, education and health which ultimately reduce TFP thus decreasing output.

Figure 4: Total Factor Productivity



Source: Author generated using World Bank data

In 2021, there were approximately 7 million child dependents in Malawi (National Statistical Office, 2022). If the fertility rate remains constant, there will be 15.9 million child dependents by 2050 (McLean, et al., 2017). But if the fertility rate is reduced to 2.3, this number is projected to fall to 9.6 million (RAPID, 2017). In order to equip the young population with required skills, Malawi's education sector would need to improve. Currently, there is a shortage of school teachers which is only exacerbated by the growing population (Palamuleni, 2017). Similarly, Malawi does not possess an adequate amount of permanent school buildings that can withstand heavy rains, desks and books are in short supply, and there is minimal access to electricity within schools (McLean, et al., 2017). Consequently a lack of investment in education and training could reduce Malawi's TFP and potential output.

Moreover, Malawi's current economically active population is estimated at approximately 8.3 million (National Statistical Office, 2022). In the context of rapid population growth, numerous new jobs must be created each year to support the larger number of youth entering the labour force; otherwise both unemployment and underemployment will increase. In 2015, about 250,000 new jobs were required (RAPID, 2017). If fertility remains constant, approximately 15.1 million jobs will need to be generated between 2015 and 2050 (Page, 2019). This figure can be condensed

to 12.9 million if the rate fertility decreases to 2.3 (RAPID, 2017). Regardless, this increase in unemployment could reduce potential output.

In addition, about 65% of Malawi's 3.8 million hectares of arable land is used for agriculture in order to both sustain its people and support its economy (Tchereni, Sekhampu, & Ndovi, 2013). Furthermore, the agricultural sector employs 64.1% of the country's total labour force (McLean, et al., 2017). To maintain the current levels of food production for Malawian citizens, agricultural productivity must increase. If fertility remains constant until 2050, the amount of arable land in 2050 will be abridged from 23 to 10 hectares per 100 people, compared to 13 hectares per 100 people if fertility decreases to 2.3 children per woman (RAPID, 2017). Any land or food shortages will reduce TFP and potential output.

Moreover, the lack of access to clean water in Malawi is a grave threat which can lead to poor health and even death, ultimately reducing labour productivity (McLean, et al., 2017). In 2021, the Water Board had approximately 238,000 household, institutional, and commercial water connections and community water distribution points (WHO, 2022). However, access to clean water is not dependable, as one-third of community water points are not functional (National Statistical Office, 2022). The demand for water connections will increase as the population grows. The demand for water connections in urban areas is expected to increase to 1.16 million in 2050 if the fertility rate does not change, and to about 928,000 if fertility decreases to 2.3 children per woman (RAPID, 2017).

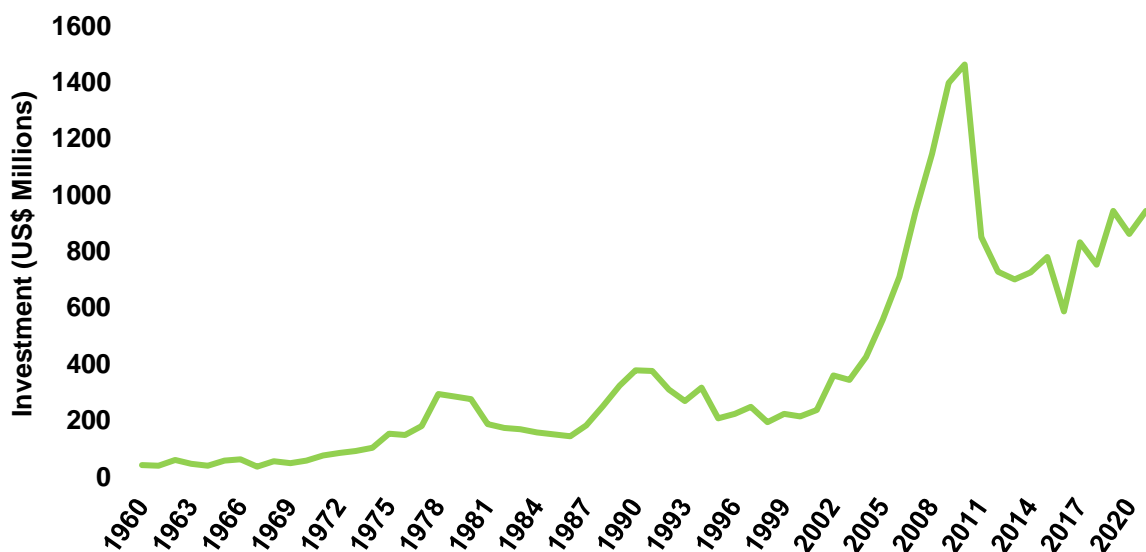
Unfortunately, this health risk is exacerbated by the terrible state of Malawi's health system. Malawi is also facing a shortage of trained health professionals. In 2021, there were about 16,000 doctors, nurses, and community health workers in the country (WHO, 2022). Additionally, there were approximately 650 hospitals and health centres in Malawi, and unfortunately nearly a quarter of the population living more than 8 kilometres from a hospital (National Statistical Office, 2022). This could be the result of Malawi's low average per capita spending on health, which for the past five years was the lowest in the Southern African Development Community (WHO, 2022). Additionally healthcare financing in Malawi remains unpredictable and predominately donor dependent, accounting for 62% of total health expenditure (National Statistical Office, 2022). In order to address these issues alongside population growth between

2015 and 2050, US\$101.1 billion would be needed if the fertility rate remains constant, compared to US\$90.3 billion if fertility is reduced to 2.3 (RAPID, 2017).

Similarly, the insufficient production of electricity in Malawi is a major disrupter of production. In 2021, only approximately 10% of Malawians had access to electricity with about 30% living in urban areas and 2% living in rural areas (National Statistical Office, 2022). The Electricity Supply Corporation of Malawi Limited (ESCOM) hopes to provide electricity for half of the population by 2050 (Page, 2019). However, projections indicate that if the fertility rate remains at 4.4 children per woman, 25.3 million Malawians which represents 59% of the population will go without electricity (RAPID, 2017). This drops to 16.8 million or 49% percent of the population if the fertility rate is reduced to 2.3 (RAPID, 2017). In addition to reduced fertility, interventions in the energy sector that increase production and access to sustainable energy are also key to ensure greater access to energy within Malawi and increase the nation's output (McLean, et al., 2017).

In order to combat these potential deficits, the levels of investment in Malawi should increase as the population increases. Increases in investment should enable increases in economic output (Klasen & Lawson, 2007). Figure 5 below shows Malawi's investment levels from 1960 to 2021. Investment levels remained under US\$400 million from 1960 to 2004, but soon after investment levels grew at a rapid rate. Eventually, investment peaked at US\$ 1396 million in 2009. This was likely due to significant loans granted to the Malawian government from the International Monetary Fund in order to increase public sector investment in an attempt to mitigate the effects of the GFC on the Malawian economy. Malawi received a loan of US\$52 million from the IMF on 3rd December 2008, then received an additional US\$53 million on 19th February 2010, finally another loan valued at US\$104 million was given on 23rd July 2012 (International Monetary Fund, 2015). Unfortunately, investment sharply declined thereafter, possibly the result of the GFC aftershocks which could not be mitigated by the increases in public investment. From 2016 investment shows an overall increasing trend which is a positive result as it may enable the improvement of resources and increases in output in Malawi.

Figure 5: Investment (US\$ Millions)



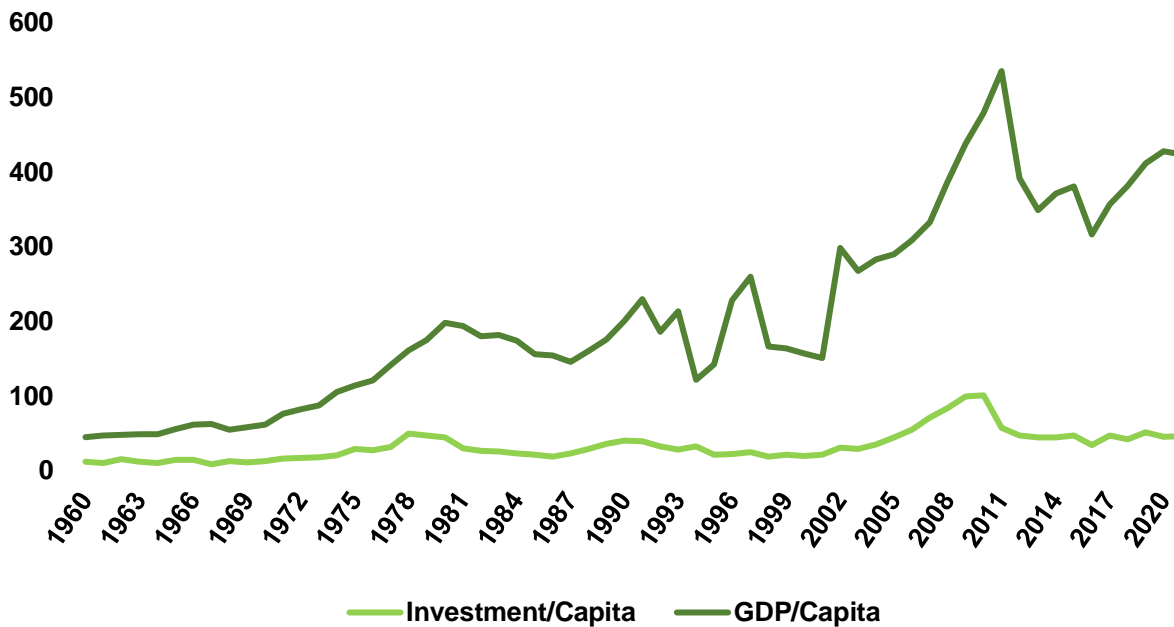
Source: Author generated using World Bank data

Based on some of the relationships identified between the variables, there are some other economic analyses that can be conducted in future. This paper investigates the economic consequences of population growth. However, Malawi appears to have challenges with increasing investment levels which could increase economic growth even with the growing population. Figure 6 below shows Malawi's investment per capita alongside GDP per capita levels over from 1960 to 2021. The investment per capita graph allows an insight into how investment levels change alongside population levels. Although investment per capita increased in the late 2000s, it fell back to its previous levels. After analysing the current state of infrastructure and services in Malawi, it is clear that there is a need for increases in investment per capita as the current levels are insufficient. Thus, the constant levels of investment per capita are concerning. Ultimately, it would be interesting to analyse the impact of population growth on investment.

Figure 6 also presents GDP per capita values over the period. It can be seen that GDP per capita values are significantly higher than investment per capita levels. Moreover, investment levels appear to stay constant even when GDP levels are increasing. This could imply that the level of investment is not significantly contributing towards GDP. This would be surprising as models such as the Solow growth model underscore the importance of investment in economic growth. Such results might imply that the

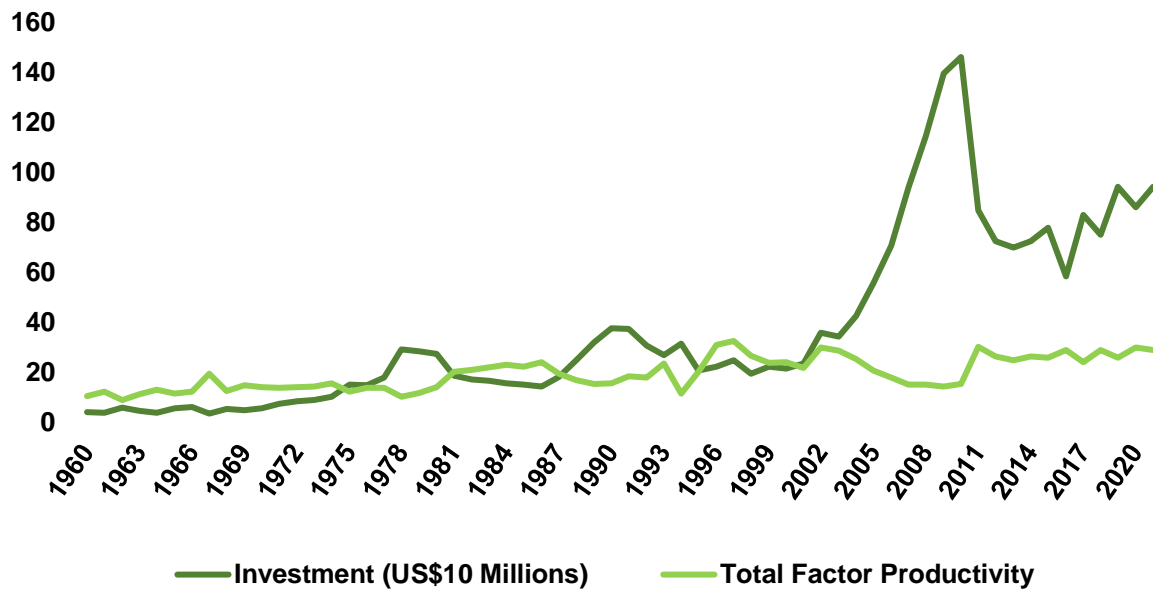
investment in Malawi is not contributing to higher levels of output and income. Therefore an additional suggestion involves the analysis of the relationship between investment and GDP in Malawi.

Figure 6: Investment Per Capita & GDP Per Capita



Similarly, another study suggestion involves analysing whether investment contributes to TFP increases in Malawi. Figure 7 below shows Malawi’s investment levels in US\$10 million alongside its TFP levels from 1960 to 2021. From the figure, it is clear that even when investment levels increase significantly, TFP does not increase at a correspondingly rapid rate. Again, this could suggest that invested funds are not channelled into activities that can increase TFP.

Figure 7: Investment & Total Factor Productivity



Section 4: Model, Data, and Method

4.1 Model and Data

This paper makes use of a Solow growth model which analyses a nation's economic growth rate over a period of time to indicate the direction of its economic evolution (Karabona & Koutun, 2013). This growth model considers the input of a nation's population, savings and investment, compared to the production of output (Sato, 1964). These variables can quite easily be altered in order to consider their per capita values (Tchereni, Sekhampu, & Ndovi, 2013). As this paper seeks to analyse the economic impacts of population growth, it employs the Solow growth model which factors in population growth. This model has informed a wide range of research, as discussed in section 2, therefore it is appropriate to employ in this paper.

The Solow (1994) model builds on classical theory but endogenises the stock of capital. It considers how levels of saving, investment, and depreciation alter the stock of capital. It is imperative to note that all variables vary with time and converge on steady state levels, which refers to a situation where the amount of capital lost by depreciation is precisely offset by saving, in the long run (Gale & Lee, 1987). The derivation of the Solow growth model is shown in Appendix 1. From the resulting equation of motion, it can be inferred that an increase in population should be accompanied by increases in capital per worker in order to achieve higher per capita

values in other variables (Solow, 1994). In a case where the population growth rate varies, the Solow growth model is slightly altered. Now, an increase in population growth rate will reduce the steady state level of capital per worker, ultimately reducing the steady state level of output per capita (Solow, 1994). Therefore, by Solow's model, a rapidly growing population would result in lower levels of capital and income per worker. However, according to the Solow model's growth rules, once the economy reaches the steady state, aggregate output grows at the same rate as the population.

Based on theoretical evidence from the Solow growth model and empirical documents, this study adopts a model similar to that used by Klasen and Lawson (2007) on the economic impact of population growth. Contrary to Klasen and Lawson (2007), this paper does not include the population growth impacts in other countries. Additionally, it does not include labour force or human capital levels as data on these variables is either unavailable or inaccurate in Malawi and the Solow model enables population to serve as a proxy for those variables. Finally, a time trend is added to generate a model that is appropriately specified.

The mathematical and econometric equations of the model are shown below. Note that in each equation L placed before a variable denotes the natural log of that variable is engaged. The mathematical model can be presented as follows:

$$LGDP_t = f(LPOP, LINV, LTFP, IMF) \dots \dots \dots (1)$$

The econometric model can be specified as follows:

$$LGDP_t = \alpha_0 + \alpha_1 LPOP_t + \alpha_2 LINV_t + \alpha_3 LTFP_t + \alpha_4 IMF_t + \varepsilon_t + t \dots \dots \dots (2)$$

Where, LGDP represents the natural logarithm of GDP per capita, LPOP represents the natural logarithm of population, LINV represents the natural logarithm of the level of investment, LTFP represents the natural logarithm of total factor productivity and IMF refers to the dummy variable which indicates the years in which Malawi received loans from the international monetary fund, α_0 is the drift component, ε_t is the disturbance term, and t is the time trend.

This paper uses secondary annual data from the period 1960-2021 from the World Bank and International Monetary Fund to estimate the model. The main independent variable is the level of population in absolute terms. The dependent variable is output

per capita, where GDP per capita is used as a proxy. The other explanatory variables include annual investment levels, TFP which compares total outputs relative to the total inputs used in the production process, and a dummy variable which takes on a value of one in years in which Malawi received loans from the IMF to mitigate the negative effects of the GFC (International Monetary Fund, 2015). All monetary variables are measured in constant United States Dollars sourced from the World Bank, where the base year is 2015. The World Bank converted monetary data in Malawi Kwacha using corresponding exchange rate data for each year. Table 1 below presents the variables and the expected signs of each coefficient.

Table 1: Presentation of Variables

Variable	Description	Data Source ¹	Expected Sign
GDP	Annual Gross Domestic Product (US\$/Capita)	The World Bank	
POP	Population (Millions)	The World Bank	Negative
INV	Annual Investment (US\$)	The World Bank	Positive
TFP	Total Factor Productivity	The World Bank	Positive
IMF	Dummy variable which takes on the value 1 in years IMF loans were given to Malawi, and 0 otherwise.	The International Monetary Fund	Positive

Source: Author's compilation from the literature review

Table 1 references the expected relationships between the variables according to the theoretical discussions. Population and GDP per capita levels are expected to have a negative relationship. According to the Solow model, higher population growth results in lower capital per worker and income per capita, thus implying a decrease in GDP

¹ The World Bank data was sourced from The World Bank DataBank at <https://databank.worldbank.org> and The International Monetary Fund was sourced from The International Monetary Fund at <https://data.imf.org>

per capita. Alternatively, investment and GDP per capita are expected to have a positive relationship. Higher levels of investment would allow the growth of capital to keep up with the growth of the population and labour force, ultimately allowing an increase in capital per worker and therefore output per capita. Similarly, high levels of productivity are expected to increase GDP per capita growth. This occurs because higher productivity rates allow for a higher amount of output at each level of inputs in comparison to lower levels of productivity, thus creating an expected positive relationship between the two variables. Finally, the IMF loans granted to Malawi are expected to have a positive relationship with GDP per capita as these loans would contribute towards investment and likely economic growth.

4.2 Method

This paper uses the annual data discussed in section 4.1 and employs an approach to cointegration to estimate the model. The ARDL approach to cointegration is used in this study as it is preferred for several reasons. First, endogeneity is reduced because of the elimination of residual correlation as each of the underlying variables exists in one long-run relation equation (Pesaran & Shin, 1998). Second, the ARDL approach to cointegration is appropriate in instances where there are small sample sizes and it can produce reliable results in data series that are stationary at levels, first difference or both (Nkoro & Uko, 2016). In other words, this approach allows for the analysis of data that is time invariant, variant or the analysis of both of these types of data simultaneously. Third, the ARDL approach to cointegration can identify single co-integration vectors in the presence of several (Nkoro & Uko, 2016). Finally, the ARDL approach to co-integration can be re-parametrized through a linear transformation in order to derive the Error Correction Model (ECM), which displays the adjustment from a short-run shock to a long-run equilibrium (Pesaran & Shin, 1998). Therefore, the ECM produces short-run results that do not contain long-run information.

Before estimating the ARDL model, unit root and cointegration tests are run. To prevent spurious regression, this paper tests for unit roots using the Augmented Dickey Fuller and Phillip Perron methods (Pesaran & Shin, 1998). These tests examine whether the coefficients of estimates are stationary. In a case where a coefficient is less than the critical value, it is concluded that the variable is non-

stationary (Ng & Perron, 2001). On the other hand, the underlying series are stationary when the coefficient is greater than the critical value (Ng & Perron, 2001).

The ARDL bounds test approach to integration is employed to investigate the existence of a long-run relationship between the dependent and independent variables. Given that the time series has variables are either I(0) or I(1), that is, mixed orders of integration, the ARDL bounds test uses the following null and alternative hypotheses to determine whether there is cointegration amongst the variables specified in equation 3 by placing restrictions on the estimated long-run coefficients shown (Pesaran, Shin, & Smith, 2001).

$$H_0: \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = 0$$

$$H_A: \beta_1 \neq 0; \beta_2 \neq 0; \beta_3 \neq 0; \beta_4 \neq 0; \beta_5 \neq 0$$

Rejecting the null hypothesis at appropriate critical values indicates the presence of cointegration between the variables and vice versa. Conversely, a test statistic that is between I(0) and I(1) critical values infers an inconclusive result (Ng & Perron, 2001). Once cointegration is established, long-run and short-run relationships can be determined based on the short-run outcome, containing the error correction term which reveals the rate of adjustment toward the long-run equilibrium (Nkoro & Uko, 2016). If the error correction term is negative and significant, cointegration exists (Pesaran, Shin, & Smith, 2001). Subsequently, both the short-run and long-run ARDL models are estimated.

With this method the paper can estimate the long run equation and the error correction model. The ARDL representation of equation (2) in section 4.1 is specified as:

$$\begin{aligned} \Delta LGDP_t = & \alpha_0 + \sum_{i=1}^n \alpha_{1i} \Delta LGDP_{t-1} + \sum_{i=0}^n \alpha_{2i} \Delta LPOP_{t-i} \\ & + \sum_{i=0}^n \alpha_{3i} \Delta LINV_{t-i} + \sum_{i=0}^n \alpha_{4i} \Delta LTFP_{t-i} + \beta_1 LGDP_t + \beta_2 LPOP_t + \beta_3 LINV_t \\ & + \beta_4 LTFP_t + \beta_5 IMF_t + \phi ECT_{t-1} + \varepsilon_t + t \quad \dots \dots \dots (3) \end{aligned}$$

Where Δ represents the first difference operator,

Section 5: Empirical Analysis

5.1 Descriptive Statistics

Table 2 presents a summary of the descriptive statistics of the variables employed in this study. Population is quoted in millions, investment values are quoted in millions of US dollars. Over the period of study, Malawi's population was 9.64 million on average, with a large range of 3.65 million to 20.38 million. GDP per capita was US\$209.79 on average, ranging from US\$44.52 to US\$534.95. Investment levels had a mean of US\$374.08 million and a large range with and a maximum value of US\$1462.57 million and a minimum of US\$35.79 million. Finally, TFP was 1.95 on average but reached a maximum of 3.26 during the period.

Table 2: Descriptive Statistics

	POP	GDP	INV	TFP
Mean	9,64	209,79	374,08	1,95
Median	9,50	174,70	242,47	1,90
Maximum	20,38	534,95	1462,57	3,26
Minimum	3,65	44,52	35,79	0,89
Standard Deviation	4,70	128,77	350,16	0,65

Source: Authors computation using World Bank data

5.2 Time Series Stationarity Tests (Unit Root Tests)

The results of the Augmented Dickey-Fuller (ADF) test and Phillip-Perron (PP) test for time series stationarity are shown in Table 3.1 and Table 3.2 below. Table 3.1 and 3.2 include the results of the unit root tests without and with a trend respectively. The test results show that the variables are of mixed order, and none of the variables have two unit roots. Therefore, the ARDL model is appropriate as this model does not require all variables to be the same order of integration and necessitates the absence of variables with two unit roots (Nkoro & Uko, 2016).

Table 3.1: Unit Root Test Results Without Trend

Variables	Augmented Dickey Fuller Test			Phillip Perron Test		
	Level	First Difference	Order of Integration	Level	First Difference	Order of Integration

LGDP	-1,0699	-8,1002	I(1)	-1,1367	-8,5368	I(1)
LPOP	-0,4277	-3,0552	I(1)	-0,1397	-2,4405	I(1)
LINV	-1,1742	-8,1177	I(1)	-1,2072	-8,1143	I(1)
LTFP	-2,7526	-9,7568	I(0)	-2,7526	-11,1218	I(0)

Source: Authors computation using EViews 12

Note: All tests are at the 10% level of significance: Computations include an intercept but no trend.

ADF critical level value = -2,5926 ; ADF critical first difference value = -2,5931

PP critical level value = -2,5926 ; PP critical first difference value = -2,5931

Table 3.2: Unit Root Test Results With Trend

Variables	Augmented Dickey Fuller Test			Phillip Perron Test		
	Level	First Difference	Order of Integration	Level	First Difference	Order of Integration
LGDP	-2,7714	-8,0683	I(1)	-2,7771	-9,1385	I(1)
LPOP	-1,2892	-3,0252	I(1)	-2,1026	-2,4307	I(1)
LINV	-2,4209	-8,0801	I(1)	-2,7489	-8,0785	I(1)
LTFP	-4,2385	-9,6723	I(0)	-4,2336	-11,0029	I(0)

Source: Authors computation using EViews 12

Note: All tests are at the 10% level of significance: Computations include an intercept and trend.

ADF critical level value = -3,1707 ; ADF critical first difference value = -3,1715

PP critical level value = -3,1708 ; PP critical first difference value = -3,1715

5.3 Auto-Regressive Distributed Lag (ARDL) Test

5.3.1 Joint Cointegration Test (ARDL Bounds Test)

The series has different orders of integration, that is, a combination of level and first difference stationary series, thus a joint cointegration test is necessary to establish a long-run relationship between the variables. The suitable test for cointegration is the Bounds Test proposed by Pesaran, Shin, & Smith (2001). The null hypothesis states that there is no cointegration whereas the alternate hypothesis is that there is joint cointegration. Table 4 below presents the results of the ARDL Bounds Test for joint cointegration. The test statistic is higher than the upper bound at the 10%, 5%, 2.5% level and at the 1% level. Thus, the null hypothesis can be rejected and it is concluded that there is joint cointegration. Therefore, there is a long-run relationship between the variables and we can proceed with both long-run and short-run ARDL model estimates.

Table 4: ARDL Bounds Test

LGDP(LPOP,LINV,LTFP, IMF) Significance	Lower Bound I(0)	Upper Bound I(1)
10%	3,19	4,31
5%	3,77	4,95
2,5%	4,42	5,67
1%	5,07	6,39
Calculated F statistic = 11,26 K = 4	There is joint cointegration	

Source: Computed by author using EViews 12

5.3.2 Long-Run Estimation

Table 5 below presents the summarised results of the estimated ARDL model parameters in the long-run. The results reveal that a one percent increase in population is associated with a 0.39 percent decrease in GDP per capita in the long run. However, this result is not significant at the 10% level. Therefore the finding cannot conclusively confirm or contradict the predictions of the Solow model, which said that GDP per capita would decrease with population growth. Similarly, it cannot approve or dispute the findings of researchers such as Yao, Kinugasa, and Hamori (2013) and Klasen and Lawson (2007) who analysed the relationship in China and Uganda respectively. Ultimately, the effect of population growth on GDP in Malawi cannot be irrefutably stated.

A one percent increase in investment increases GDP per capita by 0.09 percent but this result is not significant. This is a surprising result as Solow emphasises the role of investment in increasing output. However, it resembles the findings of Higgins and Williamson (1997) who found that investment levels in countries with growing populations and high youth dependency ratios are often inadequate in contributing to economic growth. Moreover, it could reveal the insufficient investment in Malawi as explained in Section 3 which is concerning.

A one percent increase in total factor productivity is associated with a 0.04 percent increase in GDP per capita at the 1% significance level. This matches the theoretical expectations as more productive factors yield more output. This is an important finding for policymakers as any measures taken to increase factor productivity, such as

improved skills training, education, and healthcare will result in increases in GDP per capita.

Years in which Malawi received loans from the IMF had 0.02 percent higher GDP per capita levels than years where these loans were not received and this result is significant at the 10% level. This is an expected result as the loans would increase Malawi's income levels. This also suggests that loans are used for their intended purpose.

Finally, the constant term and time trend are both positive and significant which means GDP per capita shows a slightly positive trend in the long run. This suggests that there is economic growth in Malawi which could gradually improve standards of living.

Table 5: Results of ARDL Long-Run Model (1, 1, 1, 0, 0)

Variable	Coefficient	Standard Error	T-Statistic	P-Value
LPOP	-0,3863	0,2423	-1,5945	0,1169
LINV	0,0882	0,0757	1,1653	0,2492
LTFP	0,0395	0,0146	2,6968	0,0094
IMF	0,0218	0,0112	1,9457	0,0571
CONSTANT	2,3539	1,1240	2,0941	0,0411
TREND	0,0067	0,0021	3,0972	0,0031

Source: Computed by the author using EViews 12

5.3.3 Short-Run Estimation

Table 6 below presents the speed of adjustment derived from the Error Correction Model (ECM) version of the ARDL analysis or the short-run estimates. The results reveal that a one percent increase in population is associated with 0.47 percent decrease in GDP per capita in the short run and this result is significant at the 10% level. This result is larger than the long-run result and as it is a statistically significant result, it contradicts the findings of other researchers Yao, Kinugasa, and Hamori (2013) and Klasen and Lawson (2007). Consequently, this negative relationship confirms the predictions of the Solow growth model. This outcome is worrying as it shows that GDP growth is not in line with population growth in the short run. Additionally, this implies that average standards of living are lowering in Malawi.

A one percent increase in investment increases GDP per capita by 0.93 percent in the short run and this result is significant at the 1% level. This figure is higher than the long-run finding, however it is only statistically significant in the short run which then corroborates the Solow model's emphasis of the role of higher investment levels in increasing output. This highlights the need for measures in Malawi that increase investment in the short run.

Correspondingly, a one percent increase in total factor productivity is associated with a 0.04 percent increase in GDP per capita in the short run at the 5% significance level. This is similar to the long-run effect and maintains the same sign. Again, this shows that any measures that increase factor productivity will lead to increased output in Malawi in the short run.

Years in which Malawi received loans from the IMF had 0.02 percent higher GDP per capita levels than years where these loans were not received. This result is significant at the 10% level and very comparable to the long-run result. Once more, this shows that the IMF loans boost the income and output levels in Malawi.

Again, the constant term and time trend are both positive and significant which means GDP per capita shows a slight positive trend in the short run. This suggests slight economic growth in the short run.

In addition, the results show that the ECM coefficient is negative and significant at the 10% level, which confirms the existence of a long-run relationship between GDP per capita and the explanatory variables in the analysis. The coefficient of adjustment suggests that about 47% of any short-run shock is corrected within the period of study. Moreover, the R-squared value implies that 85% of the variation in GDP per capita is explained by the independent variables.

Table 6: Results of Error Correction Model (1, 1, 1, 0, 0)

Variable	Coefficient	Standard Error	T-Statistic	P-Value
DLPOP	-0,4745	0,2423	-1,9583	0,0556
DLINV	0,9303	0,2530	3,6781	0,0006
DLTFP	0,0396	0,0171	2,3064	0,0251
DIMF	0,0209	0,0108	1,9419	0,0576

CONSTANT	2,3538	1,0047	2,3428	0,0183
TREND	0,0066	0,0032	2,0625	0,0458
ECM(-1)	-0,4728	0,2566	-1,8429	0,0726
R-squared = 0,8532				

Source: Computed by the author using EViews 12

5.4 Diagnostic Tests

Table 7 below presents diagnostic tests. Diagnostic tests are carried out to corroborate the reliability of the results. The null hypothesis cannot be rejected at the 10% level in the LM test, thus there is no autocorrelation. Similarly, the null hypothesis is not rejected at the 10% level under the ARCH homoscedasticity test, therefore there is homoscedasticity. The Jaque-Bera normality test results show that the null hypothesis cannot be rejected at the 10% level, therefore the model is normally distributed. The null hypothesis is rejected at the 5% level in the Ramsey Reset Test, which means there may be an omitted variable bias in the analysis.

Table 7: Diagnostic Tests

Test	Hypothesis (H0)	Results
LM Test	No Autocorrelation	0,6039 (0,5506)
Ramsey Reset Test	Model Correctly Specified	2,4932 (0,0159)
Heteroscedasticity Test (ARCH)	Homoscedasticity	0,0621 (0,8040)
Jaque-Bera Normality Test	Normally Distributed	0,2821 (0,8684)

Source: Computed by the author using EViews 12

Note: Results presented include t-statistics with probability in parentheses.

5.5 Structural Stability Tests

The Cumulative Sum of Recursive Residuals (CUSUM) and Cumulative Sum of Squared Recursive Residuals (CUSUM of Squares) tests are applied to the residuals of the ECM in order to determine the consistence and stability of the model (Turner, 2010). The CUSUM Test appraises any systemic variations caused by the coefficients in the regression, whereas the CUSUM of Squares Test evaluates the stability of the coefficients' constancy (Turner, 2010). If there is a structural break within the period, the test values fall outside of the critical limits of the tests and this must be accounted for in the analysis through the use of a dummy variable that takes the value of one in the years that possess structural breaks (Ploberger & Kramer, 1990).

The results of the CUSUM and CUSUM of Squares tests are shown in Appendix 2. The test values of both tests fall within the 5% critical bounds as shown by the graphs in Appendix 2. Consequently, the model is structurally stable and there are no structural breaks that have not been accounted for in the study.

Section 6: Summary and Conclusions

7.1 Conclusion

This paper carried out an empirical analysis on the economic consequences of population growth in Malawi using World Bank data from 1960 to 2021. The results were generated using the ARDL approach. The results show that increases in population levels result in decreases in GDP per capita in the short run. This is a worrying result as the population of Malawi is expected to increase considerably by 2050. It also highlights the need to introduce policies that reduce fertility levels in Malawi. Conversely, increases in investment only contribute positively towards GDP per capita in the short run which raises the need to evaluate why investment is not contributing to increases in GDP per capita in the long run. Perhaps there is need to invest in areas such as education, health, and infrastructure which can directly contribute to higher output levels. Similarly, increases in TFP lead to increases in GDP per capita in both the short run and long run. This highlights the importance of introducing policies that increase TFP in Malawi as this would escalate Malawi's economic growth. Overall, the Malawian government should either reevaluate their laissez-faire stance on fertility in order to reduce population levels or undertake investments that enable the sustenance of the growing population.

7.2 Policy Implications

The data shows that Malawi's population growth is associated with decreases in GDP per capita in the short run. Therefore, Malawi needs to implement policies and programs that assist in meeting their reproductive intentions. For example, through increased use of voluntary family planning, developing programs that keep girls in school, strengthening access to social services, and improving healthcare systems. With policies such as these in place, slower population growth can lead to economic growth and generally better standards of living through improved food security, enhanced health services, and greater access to social services for a more prosperous population.

The contribution of investment to GDP per capita was significant in the short run but not the long run which could substantiate the idea that there are various misdirected investments in Malawi. Therefore, the Malawian government could increase its investment in vital infrastructures and services such as schools, hospitals, power generation, and factories in order to sustain the current population and increase TFP levels. As the analysis found that increases in TFP lead to increases in GDP per capita in both the short run and long run, this investment could increase Malawi's economic output and average incomes.

7.3 Study Limitations

This study may have a few shortfalls. First, there may be some issues surrounding the accuracy of the data. For example, investment figures may be inaccurate as some government officials may exaggerate the volume of investments in order to gain citizen's approval or favour (Oswald, Li, McNeil, & Trimbath, 2011). Second, leaving out figures for labour force participation and human capital under the assumption that population can serve as a proxy for these may have led to an incomplete representation of the situation in Malawi. This could result in an omitted variable bias in the analysis which could explain why the Ramsey Reset Test rejected the null hypothesis at the 10% level. Perhaps another exploration can be conducted once adequate figures for labour force participation and human capital are available for Malawi.

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APPENDIX

Appendix 1

Solow Growth Model Derivation

Under the basic model, labour supply and technological progress are fixed. The production function is given as:

$$Y = F(K, L) \dots \dots \dots (1)$$

Where Y is output, K is capital stock, and L is labour. Note that the production function can be multiplied by a constant factor that represents productivity. Because of the assumption of constant returns to scale, output and capital can be divided out by the labour force in order to obtain output and capital in per capita terms. These terms are denoted in lower case letters.

Output per worker is denoted as:

$$y = \frac{Y}{L} \dots \dots \dots (2)$$

And capital per worker is denoted as:

$$k = \frac{K}{L} \dots \dots \dots (3)$$

Therefore, the production function becomes:

$$y = f(k) \dots \dots \dots (4)$$

Which infers that output per capita only depends on capital per capita.

Another important equation is the national income identity. As the Solow model assumes that there is a closed economy, government spending and net exports are not included in the model. Therefore, the national income identity can be specified as:

$$Y = C + I \dots \dots \dots (5)$$

Where Y is the national income or output, C represents consumption and I denotes investment. In per capita terms, this is written as:

$$y = c + i \dots \dots \dots (6)$$

The consumption function is written as:

$$c = (1 - s)y \dots \dots \dots (7)$$

Where s is the marginal propensity to save. This equation shows that a constant proportion of an individual's income is saved and whatever is not saved is automatically consumed.

Therefore, savings can be specified as:

$$S = y - c$$

$$S = y - (1 - s)y$$

$$S = sy \dots \dots \dots (8)$$

From these equations, it can be inferred that:

$$y = c + i$$

$$i = y - c = sy$$

Thus in equilibrium, savings are equal to investment because:

$$i = s \dots \dots \dots (9)$$

Now, using equation 4 it can be said that:

$$i = sy = sf(k) \dots \dots \dots (10)$$

Now the fundamental equation of the Solow model can be developed. This states that an increase in investment leads to an increase in capital stock and depreciation decreases the capital stock. This can be written as:

$$\Delta k = i - \delta k \dots \dots \dots (11)$$

Where δ represents depreciation. Thereafter, by inserting equation 10 into equation 11, the fundamental Solow equation of motion, which shows the evolution of capital over time, can be stated as:

$$\Delta k = sf(k) - \delta k \dots \dots \dots (12)$$

In order to include population growth, the Solow model assumes that the labour force grows at a constant rate n which is the same rate at which the population grows and is exogenous. Now, the evolution of capita must reflect the changing labour force, thus the equation becomes:

$$\Delta \left(\frac{K}{L} \right) = sf(k) - \delta k \dots \dots \dots (13)$$

Using the quotient rule of differentiation to find the change in capital per capita gives:

$$\Delta \left(\frac{K}{L} \right) = \frac{(\Delta K)L - K(\Delta L)}{L^2}$$

$$\Delta \left(\frac{K}{L} \right) = \frac{\Delta K}{L} - \frac{K}{L} \frac{\Delta L}{L}$$

$$\Delta k = \frac{\Delta K}{L} - kn$$

$$\frac{\Delta K}{L} = \Delta k + kn \dots \dots \dots (14)$$

Then setting equation 13 equal to equation 14 gives:

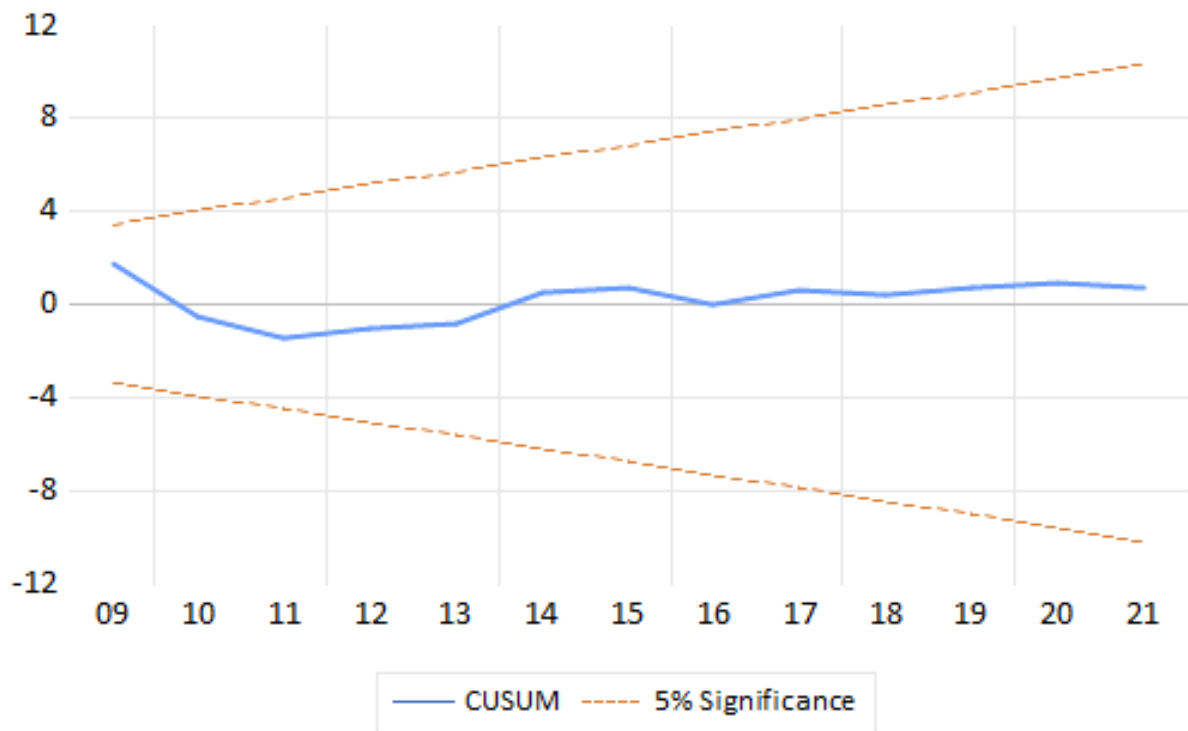
$$sf(k) - \delta k = \Delta k + kn$$

$$\Delta k = sf(k) - k(\delta + n) \dots \dots \dots (15)$$

Thus, equation 15 becomes the equation of motion with population growth and it informs us how capital changes over time and consequently how output varies over time.

Appendix 2

CUSUM



CUSUM of Squares

