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Modelling Efficacy of Demographic Changes on Capital Investment Returns: A Case of Kenya between 1965 and 2015

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Declaration and Approval

I the undersigned declare that this dissertation is my original work and to the best of my knowledge, it has not been submitted in support of an award of a degree in any other university or institution of learning.

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In my capacity as a supervisor of the candidate's dissertation, I certify that this dissertation has my approval for submission.

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Dedication

To my mum Eunice Kang'ethe for her upbringing and parental guidance. My grand-mum Mrs. Ann Kang'ethe and Aunty Ms. Rael Muli and Edward Muriithi and Moses Otieno for their unending support and Ms. Shelmith Kariuki for her training on R programming and SPSS.

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Abstract

Demographic changes have long been assumed to affect investment decisions. Little is known about the efficacy of demographic variables on capital investment despite the rising concerns in unemployment. Capital investment has been identified as important in solving the problems associated with demographic changes. There exists a huge gap in the literature between demographic changes and capital investment. Therefore, in this study, the focus is to establish the efficacy of demographics changes on capital investment returns using a case study of Kenya between for data collected between 1965 and 2015. The study specifically sorts to estimate mathematical model explaining the relationship between average age increase and capital investment, model population growth rate and capital investment returns, determine the relationship between life expectancy and capital investment returns and model dependency ratio, and capital investment returns. The study used secondary data sourced from the public website. Data analysis via SPSS, excel, and R establish that average age increase, population growth rate, life expectancy, and dependency ratio all have a positive correlation with capital investment returns since the Pearson's correlation values obtained are $0.252, 0.492, 0.305$ and 0.269 respectively. Regression analysis established that average age increase, dependency ratio, and life expectancy positively influence capital investment returns while population growth rate negatively impacts capital investment returns. Model analysis suggests that the average age increase positively impacts capital investment. The model equation for population growth rate and capital investment return have logarithmic relationships. The model analysis determines that life expectancy and capital investment return has direct proportionality. Dependency ratio and capital investment return have direct proportionality. The study concludes that demographic variables used are useful in predicting capital investment in Kenya. The study recommends an extension of the period under review and the addition of other demographic variables to add knowledge to the area.

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List of Abbreviations and Acronyms

DB	Defined-Benefit
EU	European Union
GDP	Gross Domestic Product
OLG	Overlapping Generations
PAYGO	Pay-As-You-Go
R & D	Research and Development
ROW	Rest Of the World
SPSS	Statistical Package for Social Science
TFP	Total Factor of Productivity
US	United State
OECD	Organisation for Economic Co-operation and Development

Chapter 1

Introduction

1.1 Background Information

Investment is defined as the allocation of monetary resources to assets with the aim of future gains (Patel & Vasudev, 2017). There are many investment avenues available for an investor. In this study, the focus is on capital investment, which are monetary resources allocated to a company or firm to enable its financial objectives (Goodman *et al.*, 2014).

Demographics are measurable changes in the characteristic of a population over time (Sanderson & Scherbov, 2013). Demographic changes may have a significant influence on investment decisions (Geetha & Ramesh, 2012). The study on the effect of demographic changes on investment first begun with the works of Ahn (2010). The works presented two significant hypotheses: a life-cycle investment hypothesis (people tend to invest in equities as they grow older) (Ahn, 2010, Seetharaman *et al.*, 2017); and a life-cycle risk aversion hypothesis (people tend to invest in risky business as they grow older) (Praba, 2016).

1.1.1 Average Age and Capital Investment

Age is pivotal in risk perception related to investment decision making (Chavan, 2019). For instance, age is identified to have a significant effect on investors' level of confidence in investment decisions (Siraji, 2019). Siraji (2019) asserts that young investors are risk-averse than their aging counterparts and hence tend to seek for more investment opportunities.

Age exhibits investors' risk perception and sound financial knowledge (Agarwal *et al.*, 2009). The peak financial decision-making age is 53, while financial decisions increase between 20 to 30 years old and level off from 70 to 80 (Agarwal *et al.*, 2009). Geetha & Ramesh (2012) and Ansari (2019) argued that demographic variables (age, gender, education, and occupation) are an essential factor in determining financial decision making for investors. The existing studies have not shown a mathematical relationship between average age increase and capital investment. Thus additional knowledge on the subject will help financial institutions and individuals make adept decisions.

1.1.2 Population growth and Capital Investment

African population growth, precisely that of sub-Saharan countries like Kenya, has elicited many concerns from different stakeholders (Asongu, 2013). One of the primary concerns has been the growing unemployment rate, which, if left unaddressed, would lead to bitter economic implications such as social unrest and illegal migration. Many researchers have directly and indirectly presented the basis for the needs of investments instead of the support and aid in Africa (Asongu, 2015, Darley, 2012).

Bidisha *et al.* (2020) argued that a country's population structure plays a significant role in investment decisions. Asongu (2013) also asserts that investments best handle challenges faced by surging the African population. Both studies point to the fact that population dynamics could trigger investment decisions. Earlier studies have pressed on the need for foreign direct investment, micro, and macro investment constraints, to help solve problems associated with population growth (Dollar, 2019, Tuomi, 2011). Contrary to these observations, the efficacy of population growth on capital investment decisions has not been addressed.

1.1.3 Life expectancy and Capital Investment

Just like the average age increase, individuals tend to invest more when they perceive to live longer. Such is evident in the USA between 1926 and 1995 when investment grew as life expectancy increases (Oster *et al.*, 2012). Increased life expectancy is also associated with an increase in average age. Such has increased the likelihood of individuals' increased demand for more equities to finance their livelihood even after retirement (Erb *et al.*, 1997). However, there is no single research that has explored the efficacy of life expectancy on capital investment.

1.1.4 Dependency ratio and Capital Investment

The dependency ratio is highly significant in savings and hence affects an investment decision. The higher dependency ratio lowers financial choices, which also reduces investments (Park & Mercado, 2015). Dependency ratio has in all spheres been linked with savings. It so does the conventional wisdom (more savings implies more investments) on savings and investment applies to dependency ratio and investment (Thanoon & Baharumshah, 2007). However, the existing studies have focused on the impact of dependency ratio on foreign direct investment (Alon *et al.*, 2014, Alvi & Senbeta, 2014), and hence little is explored on the subject of capital investment.

1.2 Statement of the Problem

Several studies have attempted to link demographic factors to influence the level of investment behaviors. Investor's age has been established to have effect on investment decisions and preference (Charles & Kasilingam, 2013, Lewellen *et al.*, 1977, Mittal & Vyas, 2008). A more recent study has suggested that individuals tend to make better investment decisions as they grow older (Seetharaman *et al.*, 2017). Forecasters suggest the demographic growth of Africa will double by 2036, and such has presented geo-economic and political concern to all stakeholders (Asongu, 2013). The solution to many raising concerns among them, high unemployment rate, has lately shifted reliance on investment opportunities to accommodate this high population (Asongu, 2013, Jeon *et al.*, 2010). Economist has strongly stressed more capital investment to provide enough employment for the projected population growth (Law

& Governance, 2011, Sakbani, 2011). Economists focus on current capital investment as a key to solving problems associated with population growth has been theorized and thus lacks a robust research background: these opens-up opportunities to investigate their claims from a scientific perspective.

The human capital theory defines life expectancy as the primary asset to predict individual investment decisions (Oster *et al.*, 2012). Thus, an individual with limited life expectancy is likely to undertake capital investment decisions that are only short-term payouts. Dependency on demographic structure arises when the working population is less than the aged and children. Governments with a higher number of older people tend to spend much on aging support services such as medical expenses Fang & Wang (2005) and reduces resources for investment. Consequently, individuals with more senior dependencies tend to have fewer savings and hence lower funds for capital investment (Bidisha *et al.*, 2020).

As stated in the preceding paragraphs, not much is known about the influence of demographic variables on capital investment since the existing studies suggest a linkage between these variables and the holistic approach of investment decisions. Furthermore, in the previous studies, hardly had a study model the combined influence of average age increase, population growth rate, life expectancy, and dependency ratio. Therefore, the research focuses on modelling the efficacy of average age increase, population growth, life expectancy, and dependency ratio on capital investment in Kenya between 1965 and 2015.

1.3 Objectives

1.3.1 Overall Objective

The overall objective of the study is to model the efficacy of demographics changes on capital investment returns in Kenya between 1965 and 2015

1.3.2 Specific Objectives

The specific objectives are,

1. Estimate mathematical model explaining the relationship between average age increase and capital investment returns in Kenya

2. Model population growth rate and capital investment returns in Kenya

3. Determine the relationship between life expectancy and capital investment returns in Kenya

4. Model dependency ratio and capital investment returns in Kenya

1.4 Significance of the Study

The study will make four significant contributions. First, we will provide a direct and indirect mathematical relationship between average age increase and capital investment. Second, we will use estimates to provide models for developing a mathematical relationship between population growth and capital investment returns. Thirdly, we will use mathematical tools to show the relationship between life expectancy and capital investment. Finally, we will use mathematical modelling tools to show the relationship between dependency ratio and capital investment. Mathematical tools, which we will extensively cover in Chapter 2, will then be used to show the combined effect of average age, population growth, life expectancy, and dependency ratio on capital investment in Kenya. The result will not only add literature to demographic changes in capital investment but also add literature knowledge on the subject. Figure 1.1 summarizes the conceptual framework of the research study.

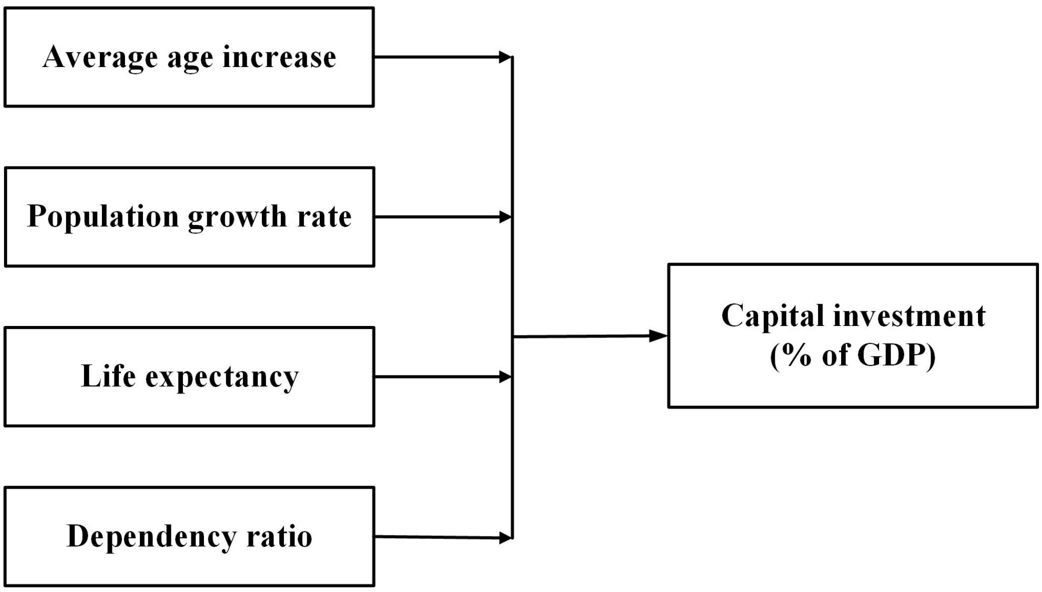

Figure 1.1: Conceptual framework for the study with demographic changes variables as independent variables and capital investment as dependent variable

1.5 Scope of the Study

The study focuses on modelling the relationship between demographic changes in capital investment in Kenya between 1965 and 2015. The research will focus on data between 1965 and 2015. The data collected will focus on average age increase, population growth, life expectancy, dependency ratio, and capital investment returns. Data analysis will exploit only relevant mathematical tools and concepts.

Chapter 2

Literature Review

2.1 Introduction

Demographic changes are composed of (Coale & Hoover, 2015): high birth and death rates leading to stagnant population and low life expectancy; low death rate leading to a high dependent population; stabilized death and birth rates leading to average age increase. U.S. census bureau reports that demographic changes fraction over the age of 65 years will increase from 17% to 27% for between 2000 and 2030 (Poterba, 2004). This is projected to increase the share of asset accumulation in the financial markets. However, whether the demographic transition patterns in ages and capital investment are linked to other demographic variables in other developing countries have remained an open question.

Demographic changes are essential in determining the countries' working age. A reduced working age is visible in the aging population (Krueger & Ludwig, 2007). This is a sign of a low mortality rate followed by falling birth rates, which reduces the population growth rate. On the contrary, a low mortality rate followed by high birth rates increases the population growth rate, thereby increases the working age. While many scholars adversely associate demographic changes to population growth rate, average age increase, life expectancy, and dependency ratio are essential characteristics. Consequently, the theoretical model links demographic changes in investment through the working-age population.

Aging population tends to have fewer children resulting in higher average age, less dependency ration, and higher life expectancy (Bloom *et al.*, 2010, 2011, Lee & Mason, 2010). The aging population has a low population growth rate. The effect of the aging population on capital investment is hard to quantify based on the intricate resulting variables created. Aging population structure results in aggregate labor supply and savings, which changes capital investment (Boersch-Supan & Winter, 2001). Reduced labour supply relative to capital rises real wages and a corresponding reduction in capital return (McGrattan & Prescott, 2013). This analogy is the main objective of this paper, that is, to show the efficacy of demographic changes (average age increase, population growth rate, life expectancy, and dependency ratio) on capital investment (percentage of GDP).

Many financial and economic models suggest linkages between demographic variables and capital investment returns. Nevertheless, these models are more to assets than capital, and hence a possible modification of the models is inevitable in order to achieve the objective of this study. The study will, therefore, borrow and modify existing models, as shown in the next sections.

2.2 Average Age and Capital Investment Returns

Higher average age occurs when there is a rise in longevity and a drop in fertility (Poterba, 2001). This affects savings as longer life stresses the economic system since the old consume more than they earn throughout their earnings. Therefore, a population characterized by older people have less investment, and consequently, less investment return is received. On the other hand, countries with a longer lifespan with little support for older people see substantial investment among the youthful age groups (Lusardi & Mitchelli, 2007). Sections 2.2.1 present models that suggest a linkage between average age increase (population aging) and assets (capital) investment return. Section 2.2.2 presents past studies showing a linkage between average age increase (population aging) and assets (capital) investment return.

2.2.1 Theoretical Review

Many economic and mathematical models suggest a linkage between demographic changes and capital or asset investment returns (Bakshi & Chen, 1994, Manton *et al.*, 2007, Ríos-Rull, 2001). The main challenge has been to show the linkage between the aging population in the developing countries and capital investment return. (Poterba, 2001) developed a simple overlapping-generation model that shows the basics understanding of demographic changes on investment return. Poterba (2001) model assumes individual work when; young (ψ) and old (α). If we normalize the production while working on a unit price of a good, and assuming the presence of a durable capital (with a non-depreciating values and fixed supply), and rate of saving out of labor income for the young is fixed at ξ then asset demand when the total number of young workers Λ_ψ is given by $\Lambda_\psi * \xi$. If we fix the durable asset $\mathcal{K}$, then the prices of these asset relative to the unit price of good ρ must be such that (Poterba, 2001),

$$\rho\mathcal{K} = \Lambda_\psi \xi. \tag{2.1}$$

Equation (2.1) suggests that an increase in the young population yields a rise in the size of young workers, which drives the asset prices high to counteract the higher demand for financial asset holding and fixed physical supply of capital. This will have a greater impact on the return on investment since the ψ population will purchase assets at high prices. Equation (2.1) suggests that a smaller number of young population in the economy will yield low asset prices, hence increasing return on investment.

The model described by Equation (2.1) neglects important asset pricing and return reality but still make it ideal for investment. The key assumptions include (Poterba, 2001): fixed saving rate for young workers; fixed supply of capital; close economy, that is, where there are no international capital flows; and other economic effects of population aging. A more sophisticated model would neglect a fixed saving rate for young workers and vary saving rates in expectation of future fluctuations of return. This would require an optimization model to simulate household behavior in terms of expenses that will affect savings. This would affect the prices of financial assets among the young population ψ, hence affecting investment return. This assumption suggests that if the rate of saving of workers in aged population cohort (higher average age) is lower compared to that of the younger workers (lower average age), then the demand for capital will be lower and model presented by Equation (2.1) will be inefficient in suggesting the asset investment return (Poterba, 2001).

When the capital supply is fixed, the effects of shocks on demand of asset is amplified and will impact the growth of capital stock (Davis, 2007). Abel (2001), Bakshi & Chen (1994), Davis (2007), Lim & Weil (2003) shown that by permitting the supply curve of capital goods links demography to asset prices. Bakshi & Chen (1994) also suggested that allowing variation of capital stock without any adjustment cost will allow capital to be priced at its production cost. When this happens, then demographic changes will not affect the price of financial assets. However, the reality posits that cost adjustment is inevitable, and thus capital stock will always suggest a linkage between demography and asset prices and returns (Davis, 2007, Lim & Weil, 2003).

Assuming an economy without capital flows suggests the supply of capital must be equivalent to contemporaneous demand for that capital (Poterba, 2001). Variation in the price of capital is more when there are no international capital flows and hence permit the elastic supply of capital. In reality, this scenario is not possible since globalization has allowed for full integration of rates of return, asset prices, and capital markets (Lim & Weil, 2003). Therefore, global demographic forces always affect capital markets, asset prices, and rates of return to the extent that affect the supply savings. Capital flows across a border make this assumption unattainable. However, integration of perfect capital market seems inconsistent with empirical evidence.

The model presented by Equation (2.1) does not consider the effect of change of age structure on non-financial aspects of the economy like the rate of growth productivity (playing a significant role in determining the rate of return and asset values). Cutler *et. al.* (1990) suggests that there exists a linkage between improvement in rate of productivity and age structure, then other factors linking demographic changes to equilibrium factor returns would have little effect.

2.2.2 Empirical Review

Empirical evidence has shown a strong correlation between the country's investment rate of return and saving rate (Davis (2007), Poterba (2001) suggests that average age dynamics are linked to saving rate). Feldstein & Horioka (1979), Obstfeld & Rogoff (2000), Taylor (2002) present a link between capital market and domestic population structure and demand for financial assets.

The effect of population ageing have been explored by other studies (average age increase) on asset markets in stylized models trying to incorporate a more realistic description of behavioural saving and determination of asset price, which also describes asset return (Abel, 2001). The models overlap generations where the population is assumed to live for long years and formulate rational life-cycle plans. Abel (2003) presented result-based overlapping generation model with fluctuated supply capital. The model relatively assumes the rise and fall of average age, which leads to a reduced rate of return, contrary to a steady-state economy with a relatively stable average age.

Brooks (2002), Geanakoplos *et al.* (2004), Poterba (2004), Yoo *et al.* (1994) presented models that suggest that demographic changes affects capital market returns. Although the findings are similar across all these models, the magnitude of varies. For instance, Brooks (2002) model assume individuals lives depend in: childhood; young working age; older working age; and retirement. Childhood is characterized by dependence on the young workers. Workers supply inelastic labor and receive after-tax wage. Workers consume a fraction of their after-tax wage and invest the rest based on risky capital based on portfolio decision and safe bonds. Retirees only consume their savings. In developed system (countries), retirees are paid Defined-Benefit (DB) or retirement benefit subjected to existing wages at a replacement rate β. More specifically, young worker in time t maximizes expected life time utility in Equation (2.2) to budget constraints in young working age Equation (2.3), old working age Equation (2.4) and retirement Equation (2.5) (Brooks, 2002):

$$\Omega_t = \upsilon \left(1+\chi_t\right) \frac{\left(\mu_t^0\right)^{1-\pi}}{1-\pi} + \frac{\left(\mu_t^1\right)^{1-\pi}}{1-\pi} + \omega \delta_t \left[\frac{\left(\mu_{t+1}^2\right)^{1-\pi}}{1-\pi} \right] + \omega^2 \delta_t \left[\frac{\left(\mu_{t+2}^3\right)^{1-\pi}}{1-\pi} \right] \tag{2.2}$$

$$\left(1+\chi_t\right) \mu_t^0 + \mu_t^1 + \xi_{e,t}^1 + \xi_{\beta,t}^1 = \theta_t \left(1-\zeta_t\right) \tag{2.3}$$

$$\mu_{t+1}^{2}+\xi_{e,t+1}^{2}+\xi_{\beta,t+1}^{2}=\theta_{t+1}\left(1-\zeta_{t+1}\right)+\left(1+\epsilon_{e,t+1}\right)\xi_{e,t}^{1}+\left(1+\epsilon_{f,t}\right)\xi_{\beta,t}^{1} \qquad (2.4)$$

$$\mu_{t+2}^{3}=\left(1+\epsilon_{e,t+2}\right)\xi_{e,t+1}^{1}+\left(1+\epsilon_{f,t+1}\right)\xi_{\beta,t+1}^{1}+\beta\theta_{t+2} \qquad (2.5)$$

where μ_t^0 is the young workers' children's consumption with discounted factor υ; ω reflects young workers' time preference based on subjective treatment, π is young workers relative risk aversion coefficient. Young workers choose consumption μ_t^1 and their children $(1+\chi_t)\,\mu_t^0$ where χ_t is cohort growth. Young workers make portfolio decision over risky capital $\xi_{e,t}^1$ and safe bonds $(\xi_{\beta,t}^1)$ and $(t+1)$ is bond return period t and denoted by $\epsilon_{f,r}$. The return on capital is not realized until period $(t+1)$ and is denoted by $\epsilon_{e,t+1}$. The output of the model represented by Equation (2.2)-(2.5) is generated by the Cobb-Douglas production function, where capital and labour are the main output. A stochastic total factor of productivity (TFP) makes returns on capital for young and workers risky. The total age distribution in time t consist of Λ_{t-1} young workers, Λ_{t-2} old workers and Λ_{t-3} retirees. The time t for child cohort is defined by $\Lambda_t=(1-\chi_t)\Lambda_{t-1}$ and the cohort growth is stochastic, β is the exogenous replacement rate and payroll taxes balances pay-as-you-go pension system and increase in the retiree to worker ratio: $\zeta_t=\beta\frac{\Lambda_{t-3}}{\Lambda_{t-1}+\Lambda_{t-2}}$. Brooks (2002) models were calibrated so that each period t represented 20 years. Brooks (2002) models were only suitable for developed countries and, therefore, inappropriate for developing countries like Kenya, where many of the model parameters are unrealistic and untenable. Besides, the proposed study focuses on modelling the average age increase on capital investment return, which makes Poterba (2001) model more useful due to its simplicity and realistic in terms of modelling parameters available.

2.3 Population Growth and Capital Investment Returns

Population growth estimation is important as a demographic device and useful statistical prediction for governments in decision making. The annual growth rate provides a measure of population growth rate (Asongu, 2013). Africa's population growth rate, accompanied by a corresponding rising unemployment rate, has posed a serious concern for the future. Only stringent investment practices have been poised to solve these problems. Consequently, a number of researchers have attempted to model population growth rate and investment returns (Asongu, 2013, Ríos-Rull, 2001, Sanderson & Scherbov, 2013, Simplice *et al.*, 2011). Section 2.3.1 presents models that suggest a linkage between population growth and investment return. Section 2.3.2 presents past studies showing a linkage between population growth and assets investment return.

2.3.1 Theoretical Review

Literature showing a direct linkage between investment and population growth rate is scanty, hence the model presented here is based on a plethora of investment types and robustness of population growth rate in investment decisions as presented by Simplice *et al.* (2011). From an aggregate investment production function (Simplice *et al.*, 2011):

$$\mathcal{M} = S\tau^b\eta^y \tag{2.6}$$

where $\mathcal{M}$ is investment variable such as economic growth, S is TFP, τ is capital stock and η is population growth rate variable measured in terms of labour. Equation (2.6) can be written as natural log form as:

$$\log \mathcal{M} = \phi + b \log \tau + y \log \eta \tag{2.7}$$

Equation (2.7) means that investment function, gross capital formation is a measure of physical capital, while the population growth rate is measured by human capital is measured in terms of growth. Equation (2.7) can, therefore, be re-arranged in terms of per capita form for any country at i where t is time as;

$$\log \mathcal{M}_{it} = b_{it} + b \log \tau_{it} + p_{it} \log \eta_{it}. \tag{2.8}$$

Equation (2.8) suggests that human capital (population growth) could improve investment by lowering the cost of labour which depends on its availability (Simplice *et al.*, 2011). The availability of labour is directly related to population growth rate; that is, the higher the population growth rate, the more available the labour and the lower the cost of labour. Therefore, countries with a high population growth rate provide higher working force and more investment, hence more economic growth. Therefore, Equation (2.8) shows a positive relationship between productivity variables and investment types (capital, human). This relationship is only significant in the long-term and has been supported widely by many researchers (Asongu, 2015, Azomahou & Mishra, 2008, Hondroyiannis & Papapetrou, 2005, Simplice *et al.*, 2011). Idea-based models (see 2.3.2) like those suggested by Aghion & Howitt (1992), Romer (1990) can take a form similar to Equation (2.6) as:

$$\mathcal{M} = \left(s_t \Phi_{\mathcal{M}t}\right)^b \tau_t^{1-b} \tag{2.9a}$$

$$\dot{s}_t = \varpi \Phi_{st} s_t \tag{2.9b}$$

Equation (2.9a) suggest that final output $\mathcal{M}$ is a function of ideas s_t, labour factor $\Phi_{\mathcal{M}t}$ and physical capital τ_t. Equation (2.9b)represent new ideas and is produced using Φ_{st} existing stock of ideas s_t. Equation (2.9a) and Equation (2.9b) shows that the total amount of labour Φ in the economy is given by $\Phi = \Phi_{\mathcal{M}t} + \Phi_{st}$. During steady-state, per capita income growth rate $\varphi_{\mathcal{M}}$ is equal to growth rate of ideas φ_s and physical capital growth rate φ_τ and is proportional to share of labour in Research and Development (R & D) sector $\xi = \frac{\Phi_{st}}{\Phi}$ and the labour force (showing population growth rate) Φ:

$$\varphi_{\mathcal{M}} = \varphi_s = \varphi_\tau = \varpi \xi \Phi. \tag{2.10}$$

Equation (2.10) predicts that increase in population growth rate while assuming other parameters constant yield a proportional increase in per capita income growth. Jones (1995*b*) used time-series evidence based on advance economics to reject prediction presented in Equation (2.10) and opined that prediction is based on counterfactual scale arrising due to assumptions the input in innovation linearly correlate to growth rate ideas. In order to eliminate the counterfactual scale effect in Equation (2.9b), the production function he suggests a replacement of production function for new ideas as,

$$\dot{s}_t = \varpi \Phi_{st}^{q} s_t^{\varepsilon}, \tag{2.11}$$

where $\varepsilon < 1$ and $0 < q \leq 1$. When $\varepsilon < 0$ then rate of innovation inversely proportional to level of knowledge; $0 < \varepsilon < 1$ shows external positive returns. Equation (2.11) removes the effect of level of population on economic growth but forests growth effect of population growth rate. Therefore, increasing exogenous growth rate of population (n) while maintaining other parameters constant yields a proportional rise in economic growth rates, that is,

$$\varpi_{\mathcal{M}} = \varpi_{\int} = \varpi_{\tau} \equiv \frac{q}{1-\varepsilon} n \tag{2.12}$$

Equation (2.12) use in predicting the growth effect of the population has been proved theoretically relevant (Huang, 2016). This paper extends the relevance of this model using empirical data for Kenya between 1965 and 2019

2.3.2 Empirical Review

Many studies have exclusively focused on population growth and economic growth, limiting studies that focus on population growth and investment. However, since investment is exogenous to economic growth, hence studies and models linking population growth and economic growth are used instead. Existing studies showing the relationship between economic growth and population growth are based on the reconciliation of theoretical prediction with empirical evidence (Samargandi *et al.*, 2015). This is opposed to the earliest dynamic economic model that observed that fertility rises as income exceeds equilibrium level and vice versa (Malthus, 1878). The divergent view has been fueled by the demographic transition that has been supported by neoclassical models, which has shifted focus from population to physical capital. The neoclassical model posits that a decrease in capital investment return has a long-run growth in population growth as long as exogenous technologies are implied correctly (Huang, 2016).

Earlier studies in the 1990s' have shown that population growth rate yields higher economic growth (Aghion & Howitt, 1992, Grossman & Helpman, 1991, Romer, 1990). Empirical data have supported this observation both from developing and advanced countries (Huang *et al.*, 2016a,b, Kremer, 1993). Literature works have, therefore, shifted to modifying this idea to eliminate errors in the model and enhance accuracy during prediction. However, even after eliminating the counterfactual scale effect in the idea-based model, growth effect and population growth rate were still found to correlate significantly positively (Huang *et al.*, 2016a). Some studies have also proved that the growth of a sector of an economy translates to population growth rate (Aghion & Howitt, 1992, Romer, 1986).

The growth rate effect of the population growth rate is intuitively nonrivaled. The notion is emphasized by Huang (2016), who asserts that a larger population enunciates many ideas, which would translate to many investment decisions, thus a higher rate of per capita income. However, this notion is not relevant when post-conflict or post-war data is used. Therefore, the model should show a decline in the economic growth rate after wars. These inconsistencies in the theoretical and empirical evidence is not a surprise since idea-based models treat human capital exogenously. In this paper, we sort to the model effect of population growth rate on capital investment return in Kenya. By doing this, we will help fulfill the study objective, and add knowledge to the field and inform policymakers since no such study has been done in Kenya before.

2.4 Life Expectancy and Capital Investment Returns

Just like population growth, life expectancy is associated with an increase in investment exogenously through economic growth (Boucekkine *et al.*, 2007a, Cervellati & Sunde, 2011). Life expectancy has been positively and negatively correlated with per capita income (Azomahou *et al.*, 2009, Boucekkine *et al.*, 2007a). Life expectancy is also associated with mortality rate, which is believed to have a positive effect on per capita as it increases the productivity of human capital (Cervellati & Sunde, 2011). However, when other productivity factors of production are assumed constant and at the macro level, then lower mortality rates affect income per capita negatively. Many studies have shown that low mortality or life expectancy positively correlates with per capita income only at micro-level (Cervellati & Sunde, 2011, Jayachandran & Lleras-Muney, 2009, Lorentzen *et al.*, 2008). Contrary, some studies have shown that higher life expectancy increases aggregate income, which triggers population growth, thus having a negative causal effect on per capita income (Acemoglu & Johnson, 2007). Section 2.4.1 presents models that suggest a linkage between life expectancy and investment return. Section 2.4.2 presents past studies showing a linkage between life expectancy and assets investment return.

2.4.1 Theoretical Review

If we consider a closed-economy (no inflows) with neoclassical growth rate in period t as suggested by Acemoglu & Johnson (2007). Acemoglu & Johnson (2007) model assumed a uniquely consumed commodity with a return to scale aggregate production function (Cervellati & Sunde, 2011)

$$V_t = (X_t Z_t)^b \, C_t^{1-b} \tag{2.13}$$

where $0 < b < 1$ and $C_t \equiv C$ represent factors of production such as physical capital or land assumed to have a fixed supply in the short and medium periods, and X_t is productivity or technology in use, Z_t is Aggregated human capital given by Equation (2.14) is supplied inelastically.

$$Z_t = m_t n_t \tag{2.14}$$

where m_t is the individual level of human capital, and n_t is the population size. Improvement in life expectancy affects technology, human capital, and population size in both medium and short periods. Equation (2.15a) is the total factor of productivity, which is a product of human capital and the level of life expectancy P_t in iso-elastic form.

$$X_t = \bar{X} P_t^g|_{g \geq 0} \tag{2.15a}$$

$$m_t = \bar{m}_t P_t^h|_{h \geq 0} \tag{2.15b}$$

Low mortality rate influences population size directly since the likelihood of more people surviving until childbearing age increases and this can be captured as (Cervellati & Sunde, 2011),

$$n_t = \bar{n} P_t^j \text{ can be written as Equation (2.16b)} \tag{2.16a}$$

$$\ln(n_t) = \ln(\bar{n}) + j \ln P_t|_{j>0} \tag{2.16b}$$

Using analogy derived from Equation (2.16b) we can give the level of log per capita income as,

$$\ln(v_t) = b \ln(X_t) + \ln(m_t) - (1-b) \ln(n_t) + (1-b) \ln(C_t). \tag{2.17}$$

If we further assumed that C_t is independent from life expectancy P_t in the short and medium period, then from Equation (2.14)-Equation (2.15b), we have,

$$\ln(v_t) = R \ln(P_t) + Q_t \tag{2.18}$$

where $Q_t = (1-b) \ln(C_t) + b(\ln(\bar{X}) + \ln(\bar{z})) - (1-b) \ln(\bar{n})$ and $R = b\,(g+h) - (1-b)\,j \gtrless 0$. The model Equation (2.18) shows the major ambiguity related to the function of life expectancy in per capita income, that is, increasing P_t increases n_t, and that reduces income per capita if the factor of production is fixed and marginal productivity is reduced. The observation is similar to that of the Malthusian approach, that is, negative population effect $-(1-b)\,j < 0$ on per capita income. On the other hand, life expectancy has a positive effect on human capital and increases income per capita via productivity X and the human capital stock, $b\,(g+h) > 0$. In an attempt to remove these ambiguities associated with the effect of life expectancy on per capita income, Cervellati & Sunde (2011) developed two models based on Equation (2.18) and considered two hypothetical countries: pre-transitional and post-transitional countries. Pre-transitional countries are countries that have not gone through the demographic transition, while post-transitional are those where the demographic transition has occurred. The study findings based on statistical data noted that the effect of life expectancy on per capita income opposes pre-transitional and post-transitional countries. For instance, in pre-transitional countries, an increase in life expectancy reduces per capita income, and the effect is vice versa in post-transitional countries.

2.4.2 Empirical Review

Several studies have linked life expectancy to investment returns exogenously through per capita income. A sample of an investigation by the world bank in 1998 noted that life expectancy has a strong relationship with per capita income in countries such as Costa Rica where life expectancy is estimated at 77 years and are 12 times richer than Sierra Leone where life expectancy was estimated at 37 years (Azomahou & Mishra, 2008). **?**, through parametric panel data, established that life expectancy is exceedingly significant in economic growth (investment return). Chakraborty (2004) study concluded that life expectancy strongly and positively affect capital accumulation. Kelley & Schmidt (1994, 1995) highlighted that relationship between life expectancy and economic growth via three decades panel data for 89 countries studied is complex, suggesting there exist ambiguities in the relationship. Similar findings noted by Brander & Dowrick (1994) that life expectancy contributes to economic growth in a sophisticated way and co-integrated in investment return.

Other studies based on built and tested models have also shown that the relationship between life expectancy and economic growth is nonlinear and non-monotonic (Boucekkine *et al.*, 2002, 2003, 2004, 2007b). In these models, higher life expectancy notably influences schooling time, which improves education levels and proper investment decisions. The models also negated the need for longer schooling time and related to negative economic growth. Overall, these models show there exist ambiguities related to life expectancy and investment return via economic growth. Similar results were noted by Kalemli-Ozcan *et al.* (2000), who used a stylized model to find the relationship between life expectancy and economic growth. Therefore, in this study, we show a more complicated relationship between life expectancy and investment return for Kenya using time-series data collected between 1965 and 2019.

2.5 Dependency Ratio and Capital Investment Returns

Dependency ratio (a combination of young and old individuals) inversely impacts the aggregate saving rate, which reduces the overall capacity for investing in the economy due to increased consumption needs (Salman & Zaib, 2012). This is a common occurrence in developing nations since the aging population and the young who are non-economically productive tend to consume more than they produce.

2.5.1 Theoretical Review

The aging population reduces the fraction of the working age. This is driven by a decline in death rates accompanied by falling rate of birth, which ultimately reduces rate of population growth and may turn negative in some countries. Dependency ratio following demographic changes occurs in all nations with differential extent and timing, as shown in Figure 2.1. The figure shows that while some regions are almost past the closing stages of the demographic transition process, other regions are at the beginning (Krueger & Ludwig, 2007). The figure illustrates the European Union (EU) population begins to shrink in about 2015, while the population of the US and the rest of the world continues to increase. Figure 2.2 shows that the EU population is the oldest, while the rest of the world (ROW) is the youngest based on the relative size of the working-age population. Figure 2.2 show that at the beginning (around the year 2000) rest of OECD and US have almost similar

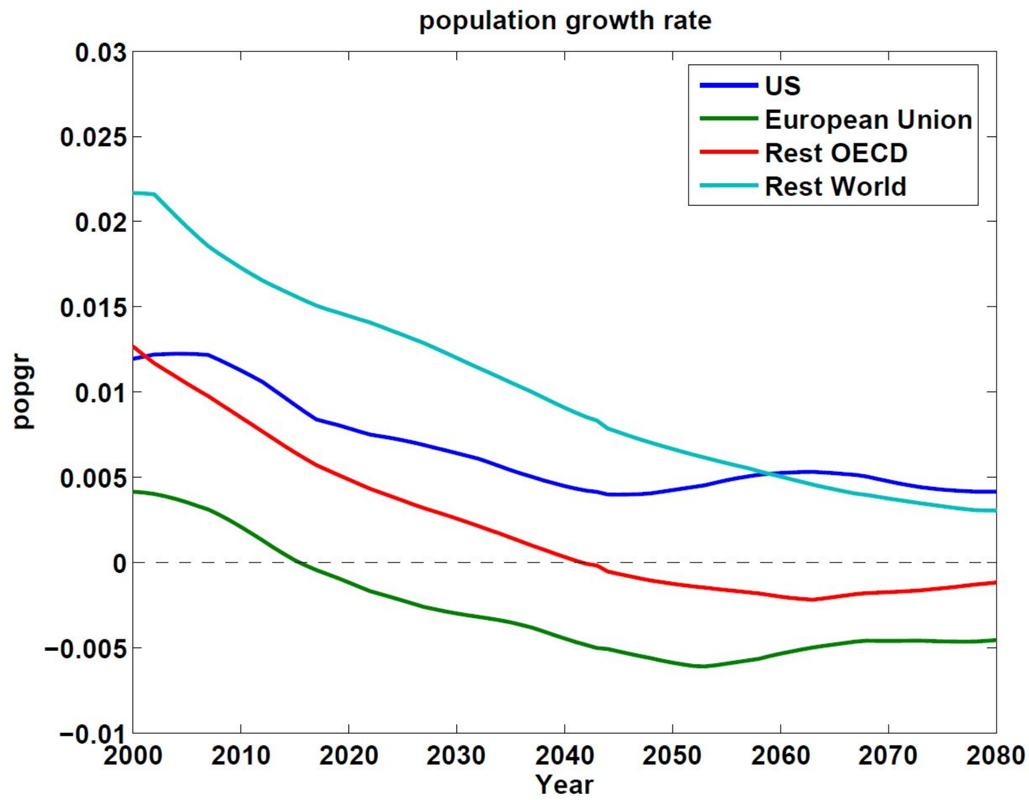

Figure 2.1: Illustration of demographic transition of population growth rate in 4 major regions that comprise of the entire world for the period 2000-2080. These 4 regions presented and forecast are US, European Union, Rest OECD, and Rest World.
Source: (Krueger & Ludwig, 2007).

working-age population ratio while at the end (around the year 2080) US and ROW will have an almost same working-age population ratio. Figure 2.2 also illustrates that in all the four regions, the working-age population ratio decreases. However, the graphical representation in the figure shows that the dynamics of demographic changes vary in all the regions; thus, the US has a steady fall than the other regions.

The demographic transition, specifically, dependency ratio, affects aggregate labor supply and aggregate savings, which ultimately changes the

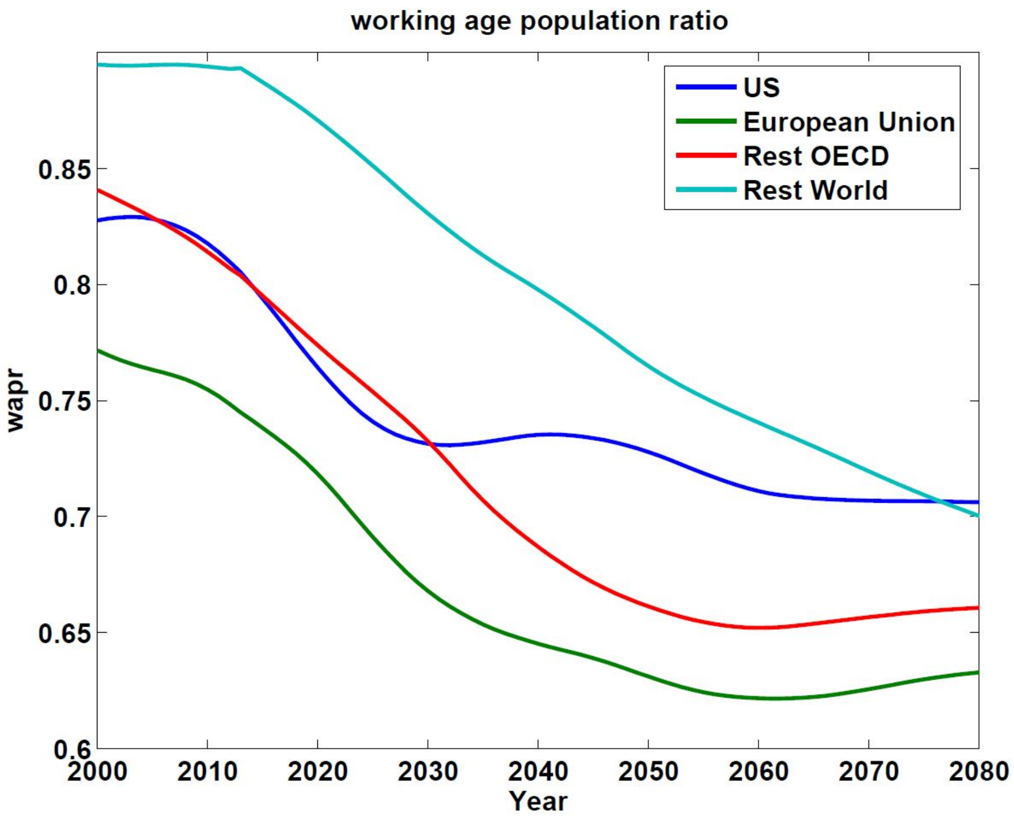

Figure 2.2: Illustration of working-age $(20-64)$ population ratio to the total adult age $(20-95)$ population in 4 major regions in Figure. 2.1 that comprise of the entire world for the period $2000-2080$.
Source: (Krueger & Ludwig, 2007).

prices of labor and capital. The scarcity of labor supply as a result of a high dependency ratio results in relative capital changes, which increases real wages and a decline in return to capital (Imai & Keane, 2004).

The populations with a higher dependency ratio derive their income from labor wages. The changes in the capital factor of prices, on the other hand, are based on endogenous uncertainty derived from some population drawing their income from returns to capital. These characteristics make the Overlapping Generations (OLG) model more suitable for modelling the dependency ratio and capital investment return. For every country i, there are $\ell_{t,i}$ young households living to two periods and have preferences over consumption $\varsigma^{y}_{t,i}$, $\varsigma^{o}_{t+1,i}$ which are represented by their utility function (Krueger & Ludwig, 2007)

$$\log(\varsigma^{y}_{t,i}) + \log(\varsigma^{o}_{t+1,i}). \tag{2.19}$$

If in the first period $\ell_{t,i}$ work for a wage $\varrho_{t,i}$ and in the second period $\ell_{t,i}$ retire and receive social security benefits $\vartheta_{1+1,i}$ financed by payroll taxes on labour income. Therefore, if σ_t is savings for $\ell_{t,i}$ first period, then budget constraint can be represented by

$$\begin{aligned} \varsigma^{y}_{t} + \sigma_t &= (1 - \iota_{t,i})\,\varrho_{t,i} && \text{(2.20a)} \\ \varsigma^{o}_{t+1} &= (1 + \gimel_{t+1})\,\sigma_t + \vartheta_{t+1,i} && \text{(2.20b)} \end{aligned}$$

where $\gimel_{t+1}$ is the real interest rate between period t and $t+1$ and $\iota_{t,i}$ is the social security tax rate in country i. If there is free flow of capital across countries and an equal real interest rate across the world, then country i will have a production function as,

$$\Psi_{t,i} = K^{r}_{t,i}\left(X_i \Im_t \ell_{t,i}\right)^{1-r}, \tag{2.21}$$

The X_i is the country i technology level, and $\Im_t = (1 + \daleth)^t$ is exogenous-based growth productivity, meaning the differential technology levels are allowed across countries. Still, the growth rate is assumed constant across the countries. If the production technology of each country is operated by competitive firms whose operation depends on product and market factors such that firms maximize their profits by

$$
\begin{aligned}
1 + \gimel_t &= r k_t^{r-1} && (2.22a) \\
\varrho_{t,i} &= (1-r)\, X_i \Im_t k_t^{r} && (2.22b)
\end{aligned}
$$

where $k_t = k_{t,i} = \frac{K_{t.i}}{X_i \Im_t \ell_{t,i}}$ is the efficiency of capital stock per unit of labor. If the social security system is pure pay-as-you-go (PAYGO), which ensures the budget is balanced for all time t. Thus,

$$\iota_{t,i}\varrho_{t,i}\ell_{t,i} = \vartheta_{t,i}\ell_{t-1,i}, \tag{2.23}$$

Equation (2.23) requires that market is cleared in the world such that the capital market satisfies,

$$K_{t+1} = \sum_i K_{t+1,i} = \sum_i \ell_{t,i}\sigma_{t,i}. \tag{2.24}$$

Equation (2.24) require an equilibrium, which can be solved analytically. The solution require pre-solution of the household problem followed by aggregate of households across countries (Krueger & Ludwig, 2007). If the young population in country i have an assumed optimal saving given as (Krueger & Ludwig, 2007),

$$\sigma_{t,i} = \frac{\mathcal{B}}{1+\mathcal{B}}\varrho_{t,i}(1-\iota_{t,i}) - \frac{\vartheta_{t+1,i}}{(1+\mathcal{B})(1+\gimel_{t+1})}, \tag{2.25}$$

and the social security system have a budget constraint(Krueger & Ludwig, 2007),

$$\vartheta_{t,i} = \frac{\ell_{t,i}}{\ell_{t-1,i}} \varrho_{t,i} \iota_{t,i} = \gamma^{\ell}_{t,i} \varrho_{t,i} \iota_{t,i}, \tag{2.26}$$

where $\gamma^{\ell}_{t,i}$ is the rate of growth of young population in country i between period $t-1$ and t. $\gamma^{\ell}_{t,i}$ in Equation (2.26) measures working age to population ratio, thus higher $\gamma^{\ell}_{t,i}$[1] suggest higher ratio. We use Equation (2.22a) -(2.22a), Equation(2.25) and Equation (2.26) to get,

$$\sigma_{t,i} = \frac{\mathcal{B}(1-\iota_{t,i})(1-r)}{1+\mathcal{B}} X_i \Im_t k^r_t - \frac{\gamma^{\ell}_{t+1,i} \iota_{t+1,i}(1-r)}{(1+\mathcal{B})r} X_i \Im_{t+1} k_{t+1}. \tag{2.27}$$

If $\tilde{\ell}_t = \sum_i X_i \ell_{t,i}$ is the weighted world population efficiency, $\tilde{\mathfrak{A}}_{t,i} = \frac{X_i \ell_{t,i}}{\tilde{\ell}_t} = \frac{\tilde{\ell}_{t,i}}{\tilde{\ell}_t}$ is the relative share of the weighted country i population efficiency. Thus, weighted aggregated world population efficiency is given by $\tilde{\gamma}^N_t = \frac{\tilde{\ell}_t}{\tilde{\ell}_{t-1}} = \sum_i \mathfrak{A}_{t,i} \gamma^{\ell}_{t,i}$ (Krueger & Ludwig, 2007). Using this analogy, the capital market clearing condition can be represented by

$$\sum_i \sigma_{t,i} \ell_{t,i} = \sum_i K_{t+1,i} = k_{t+1} \sum_i X_i \Im_{t+1} \ell_{t+1,i} = k_{t+1} \Im_{t+1} \tilde{\ell}_{t+1} \tag{2.28}$$

[1]population, $Pop_{t,i}$, at time t for every country i is $Pop_{t,i} = \ell_{t,i} = +\ell_{t-1,i}$ and working age to population ratio, $wapr_{t,i}$ $wapr_{t,i} = \frac{\ell_{t,i}}{Pop_{t,i}}$ and the population growth rate, $\gamma^{Pop}_{t,i}$ is given by $\gamma^{Pop}_{t,i} = \frac{Pop_{t+1,i}}{Pop_{t,i}} = \frac{1+\gamma^{\ell}_{t,i}}{1+\frac{1}{\gamma^{\ell}_{t-1,i}}}$, where $wapr_i = \frac{1}{1+\frac{1}{\gamma^{\ell}_i}}$. Balanced demographic transition where population growth is equal to working age growth rate, that is, $\gamma^{Pop}_i = \gamma^{\ell}_i$, hence γ^{ℓ}_i measure population growth rate and working age to population ratio.

We use Equation (2.27) to derive aggregated household savings decision from countries to get,

$$\sum_i \sigma_{t,i}\ell_{t,i} = \frac{(1-r)\mathcal{B}\Im_t k_t^r}{1+\mathcal{B}} \sum_1 (1-\iota_{t,i}) X_i \ell_{t,i} - \frac{(1-r)\Im_{t+1} k_{t+1}}{(1+\mathcal{B})r} \sum_i X_i \ell_{t+1,i} \iota_{t+1,i} \tag{2.29}$$

Equation (2.29) is used in Equation (2.27) and simplified to get,

$$k_{t+1} = \mathcal{Q}_t k_t^r \big|_{\mathcal{Q}_t = \frac{r(1-r)\mathcal{B}(1-\iota_t^t)}{\tilde{\gamma}_{t+1}^{\ell}} \gamma^{\Im} \left(r(1+\mathcal{B})+(1-r)\iota_{t+1}^r\right)} \tag{2.30}$$

where $\mathcal{Q}_t$ is the proportion of the output of what is saved by an effective worker. $\iota_t^r = \sum_i \iota_{t,i} \tilde{\mathfrak{Q}}_{t,i}$ is the world population average social security contribution rate, $\gamma^X = 1 + \daleth$ is the technology growth rate for country i. Equation (2.30) describes dynamics of the aggregate capital stock when initial condition $k_0 = \frac{\sum_i \sigma_{-1,i}\ell_{-1,i}}{\Im_0 \sum_i X_i \ell_{0,i}}$ is provided for country i. The interest rate would then be given by

$$1 + \beth_t = r k_t^{r-1}, \tag{2.31}$$

and dynamics of the real interest rate,

$$1 + r_{t+1} = \left(\frac{r}{r_t}\right)^{1-r} (1 + \beth_t)^r \tag{2.32}$$

with $1 + r_0 = r k_0^{r-1}$ as the initial condition. Effective capital stock, k is given by.

$$k = \left(\frac{r(1-r)\mathcal{B}(1-\iota^r)}{\tilde{\gamma}^\ell \gamma^\Im \left(r(1+\mathcal{B}) + (1-r)\iota^r\right)} \right)^{\frac{1}{1-r}} \tag{2.33}$$

Equation (2.21) and Equation (2.33) are used to derive normalized productivity de-trended per capita out for county i as,

$$\frac{\Psi_{t,i}}{X_i \Im_t (\ell_{t,i} + \ell_{t-1,i})} = \frac{\mathcal{Q}^{\frac{1}{1-r}} \gamma_i^\ell}{1 + \gamma_i^{ell}} |_{\mathcal{Q} = \left(\frac{r(1-r)\mathcal{B}(1-\iota^r)}{\tilde{\gamma}^\ell \gamma^\Im (r(1+\mathcal{B}) + (1-r)\iota^r)} \right)}. \tag{2.34}$$

Rate of returns to saving can be related to world savings $\mathfrak{M}_t$ as,

$$\mathfrak{M}_t = K_{t+1} - K_t. \tag{2.35}$$

Equation (2.36) shows that world savings is equal to investment and can further be presented along balanced growth path analysis Krueger & Ludwig (2007) in terms of constant capital growth rate, $K_{t+1} = \gamma^\Im \tilde{\gamma}^\ell K_t$, so that Equation (2.36) becomes

$$\mathfrak{M}_t = \left[\gamma^\Im \tilde{\gamma}^\ell - 1 \right] K_t. \tag{2.36}$$

Therefore, the saving-investment rate of world population, $\mathfrak{M}r_t$, is

$$\mathfrak{M}r_t = \begin{cases} \frac{\mathfrak{M}_t}{\Psi_t} = \left[\gamma^\Im \tilde{\gamma}^\ell - 1 \right] \frac{K_t}{\Psi_t} = \left[\gamma^\Im \tilde{\gamma}^\ell - 1 \right] \frac{k_t \Im_t \sum_i X_i \ell_{t,i}}{k_t^r \Im_t \sum_i X_i \ell_{t,i}} \\ \quad = \left[\gamma^\Im \tilde{\gamma}^\ell - 1 \right] k^{1-r} = \left[\gamma^\Im \tilde{\gamma}^\ell - 1 \right] \left(\frac{r}{1+\beth} \right) = \mathfrak{M}r \\ \quad \text{or } 1 + \beth = \frac{r \left[\gamma^\Im \tilde{\gamma}^\ell - 1 \right]}{\mathfrak{M}r} \end{cases} \tag{2.37}$$

Equation (2.37) suggests that saving rate and interest rates have a negative correlation; that is, a higher increase in the saving rate leads to an increase in capital supply, thereby reducing the rate of return. From Equation (2.37), it follows that

$$\mathfrak{M}r = \left[1 - (\tilde{\gamma}^{\ell}\gamma^{\Im})^{-1}\right] \frac{r(1-r)\mathcal{B}(1-\iota^{r})}{r(1+\mathcal{B}) + (1-r)\iota^{r}}, \tag{2.38}$$

and

$$1 + \gimel = \tilde{\gamma}^{\ell}\gamma^{\Im} \frac{r(1+\mathcal{B}) + (1-r)\iota^{r}}{(1-r)\mathcal{B}(1-\iota^{r})} \tag{2.39}$$

Equation (2.39) shows a negative correlation between the interest rate and saving rate, as also shown in Equation (2.37), thus a fall in working age to population ratio $\tilde{\gamma}^{\ell}$ results to fall in the rate of return $\gimel$ in the saving rate $\mathfrak{M}r$, which results to similar intuition as those proceeding Equation (2.37). That is when the number of young people is less than older people, or a higher dependency ratio causes a shortage of labor relative to capital. Equation (2.39) provide further intuition that a rise in social security contribution rate ι^{r} accompanied by a decline in saving rates increases rate of return (Brooks *et al.*, 2005, Krueger & Ludwig, 2007). Therefore, a fall in world working age to population ratio results in a reduction in capital rate of return iff social security contribution is kept constant. However, raising the contribution rate stabilizes social security benefits and may reduce or increase the decline in rates of returns.

2.5.2 Empirical Review

Savings are essential in helping maintain levels of investment (Khan *et al.*, 1992). The decline in saving rates in many countries in the world, precisely the developing countries, relates to a higher dependency ratio. A few studies have shown the relationship between dependency ratio and capital investment returns via saving rate. A study by Krueger & Ludwig (2007) employed a multi-country large scale OLG model combining with productivity of labor and risk of mortality to model the impact of dependency ratio on the capital rate of returns in the US, Rest of OECD, European Union and ROW. The study findings noted that for the US economy, prices of return forecast a decline by 86% for the period between $2000 - 2080$ despite predicted 4.1% increase in wages. Further analysis revealed that if the US has assumed a closed economy, then rates of return would decline further, and wage increase would be less than the projected. The observation links these results to the fact that other regions in the world would age more rapidly and spill over the demographic transition in terms of higher population to working-age ratio. This would increase the factor of price changes, which would increase consumption. As a result, the younger population with little asserts with low labor productivity would gain up to 1% resulting from population aging. Consequently, the older population rich in assert would experience a decline in real returns to capital.

Li *et al.* (2007) study noted that old-age dependency rates have a negative effect on savings. Li *et al.* (2007) used panel data sourced from world bank in neoclassical and endogenous growth models to note that the dependency effect has a negative effect on savings and investment returns. The study also noted that differential demographic transition across countries explains the difference in save aggregated saving rates in the world. Salman & Zaib (2012) study links dependency and saving rates via time-series data between 1980 − 2009. The study through multiple regression analysis and Pearson correlation observed that savings and dependency rates have a negative relationship. The study also noted that savings have a positive correlation with investment. In all the listed studies above, no research has focused on modelling the mathematical relationship between dependency ratio and capital investment return in Kenya. Therefore, in this study, we show a more complicated relationship between dependency ratio and capital investment return for Kenya using time-series data collected between 1965 and 2015.

Chapter 3

Methodology

3.1 Research Type and Objective

The study aimed at modelling the efficacy of demographics changes on capital investment returns in Kenya between 1965 and 2015. The research specifically focuses on estimating the mathematical model explaining the relationship between average age increase, modelling population growth rate, determine the relationship between life expectancy and dependency ratio, and capital investment returns in Kenya. Therefore, the dependent variable of the study is capital investment return, and independent variables are average age increase, population growth rate, life expectancy, and dependency ratio.

3.2 Data Collection

The study utilized time-series secondary data for demographic variables, and capital investment return for Kenya collected between 1965 and 2015. The secondary data sources are tabulated in Table 3.1.

Table 3.1: Online variables data collection sources

Variables	Source
Average age	https://www.worldometers.info/world-population/kenya-population/
Population growth rate (%)	https://www.worldometers.info/world-population/kenya-population/
Life expectancy	https://www.worldometers.info/demographics/kenya-demographics/#life-exp
Dependency ratio (%)	https://www.worldometers.info/demographics/kenya-demographics/
	https://knoema.com/search?query=dependency%20ratio
Capital investment (% of GDP)	https://www.theglobaleconomy.com/Kenya/Capital_investment/

3.3 The Models

The research relies on the previous model described in Chapter 2 specifically Sections 2.2.1, 2.3.1, 2.4.1, and 2.5.1.

3.3.1 Average Age Increase

The model for average age increase and capital investment return is borrowed from the works of Poterba (2001) as presented in Equation 2.1, that is,

$$\rho\mathcal{K} = \Lambda_\psi \xi.$$

where ρ is the relative unit prices of durable assets, $\mathcal{K}$ is fixed supply of durable asset, Λ_ψ is the total number of young workers, ξ is a fixed saving rate out of labor income for the young population, and $\Lambda_\psi \xi$ is the asset demand. If we assume an average saving rate and $\tilde{\Lambda}_\psi$ average age increase, and ρ is endogenous to return on investment, thus return on capital investment ρ_{RCI} will be given by

$$\rho_{RCI} = \frac{\tilde{\Lambda}_\psi \tilde{\xi}}{\tilde{\mathcal{K}}}, \tag{3.1}$$

where $\tilde{\mathcal{K}}$ is the average fixed supply of assets and $\tilde{\xi}$ average saving rate corresponding to average age increase.

3.3.2 Population Growth

The literature showing a model for modelling a relationship between population growth and capital investment is extracted following model presented in Section 2.3.1. Based on the aggregate investment production function presented in Equation (2.6), we can deduce an average aggregate investment production function as follows:

$$\tilde{\mathcal{M}} = \tilde{S}\tau^b\eta^y \tag{3.2}$$

where $\tilde{\mathcal{M}}$ is capital investment return , $\tilde{S}$ is TFP, $\tilde{\tau}$ is capital stock and $\tilde{\eta}$ is population growth rate. We can transform Equation (3.2) to natural log form as:

$$\log \tilde{\mathcal{M}} = \phi + b \log \tilde{\tau} + y \log \tilde{\eta} \tag{3.3}$$

Equation (3.3) can simply be interpreted that in the investment production function, gross capital formation is a measure of physical capital. In contrast, human capital is measured by the population growth rate. Re-arranging Equation (3.3), we obtain per capita form for Kenya, where t is time as;

$$\log \tilde{\mathcal{M}}_t = \sum_{t=1965}^{2015} \left(b_t + b \log \tilde{\tau}_t + p_t \log \tilde{\eta}_t\right). \tag{3.4}$$

Equation (3.4) is used as the main model for relating population growth and capital investment return in Kenya.

3.3.3 Life Expectancy

Following the literature presented in Section 2.4.1, and we assume Kenya is a close economy with no inflows and an aggregated production function, then we can re-write Equation (2.13) as

$$V_t = (X_t m_t n_t)^b \, C_t^{1-b} \tag{3.5}$$

where $0 < b < 1$ and $C_t \equiv C$ represent factors of production such as physical capital, X_t is productivity or technology in use, m_t is the individual level of human capital, and n_t is the population size. Improvement in life expectancy affects technology, human capital, and population size in both medium and short periods. P_t denotes life expectancy. The role of life expectancy on human capital and TFP is assumed to be iso-elastic. If $X_t = \bar{X} P_t^g|_{g \geq 0}$, $m_t = \bar{m}_t P_t^h|_{h \geq 0}$ and $n_t = \bar{n} P_t^j$, we can re-write Equation (3.5) as,

$$V_t = \left(\left(\bar{X} P_t^g|_{g \geq 0} \right) \left(\bar{z} P_t^h|_{h \geq 0} \right) \left(\bar{n} P_t^j \right) \right)^b C_t^{1-b} \tag{3.6}$$

Equation (3.6) is used as the main model for relating life expectancy and capital investment return in Kenya.

3.3.4 Dependency Ratio

We follow the literature presented about the OLG model in Section 2.5.1. If we assume the Kenyan population derive their income from labor wages, and that there are no social security benefits and the periods are summed up, then the Equation (2.20a)-(2.20b) transforms to

$$\varsigma_t^y + \varsigma_{t+1}^o = \varrho_t + \Bigg((1 + \gimel_{t+1}) - 1 \Bigg) \sigma_t \tag{3.7}$$

where $\gimel_{t+1}$ is real interest rate between period t and $t+1$, $\varrho_{t,i}$ wages earned in the period t, ς_t^y is consumption by young workers at time t and ς_{t+1}^o consumption preference for the second period. Equation (3.7) is used as the main model for relating dependency ratio and capital investment return in Kenya

3.4 Data Analysis

The models are evaluated using R-Programming. Data analysis also employs The Statistical Package for Social Science (SPSS) to obtain a correlation analysis to get the causal relationship between independent and dependent variables. Analysis of Variance (ANOVA) is employed to perform model fit and establish the efficacy demographic variable changes on capital investment. Regression analysis is done to establish the linear relationship between the dependent variable and independent variables to support the findings from model analysis from Equations (3.1), (3.4), (3.6)-(3.7).

Chapter 4

Data Analysis

4.1 Introduction

The study modeled the efficacy of demographic variable changes on capital investment returns in Kenya between 1965 and 2015. Thus, data are collected (presented in Table 4.1) for independent variables (average age increase, population growth, life expectancy, and dependency ratio) and dependent variables (Capital investment). Table 4.1 5 year interval data collected between 1965 to 2015 and source.

Table 4.1: Demographic variables and capital investment data collected for the period between 1965 and 2015.

Year	AAI(%)	PGR	LE (Years)	DR	CI (% of GDP)
1965	-7.69	3.25	51.1	108.49	14.39
1970	-2.46	3.47	54	110.44	24.4
1975	-1.92	3.74	56.5	112.09	18.14
1980	-1.10	3.87	58.8	112.57	24.51
1985	-0.01	3.9	58.6	111.06	25.32
1990	2.9	3.6	55.7	106.58	24.16
1995	3.86	3.2	51.8	96.75	21.82
2000	3.74	2.85	51.7	90.56	17.41
2005	3.35	2.76	58.5	85.56	17.65
2010	2.94	2.79	62.9	83.06	20.84
2015	4.4	2.64	66.2	77.13	21.47

Item	KEY	Data Source
AAI	Average Age Increase	(World Data, 2020)
PGR	Population Growth Rate	(worldometer, 2020)
LE	Life Expectancy	(Worldometer, 2020)
DR	Dependency Ratio	(UNPD, 2020)
CI	Capital Investment	(Global, 2020)

Source: Researcher

4.1.1 General Statistical Analysis

Graphical representation of data

The general graphical trends of data collected are presented in Figures 4.1-4.5.

Figure 4.1 shows a sharp average age increase between 1965 and 1970. There was almost no change between 1970 and 1975. The average age increase gradually rises between 1975 and 1995. It then followed by a decline between 1995 and 2010, before a sharp rise to 2015. However, in general, the average age increase was negative between 1965 and 1985, while positive between 1985 and 2015.

Figure 4.2 shows a short rise in population growth rate between 1965 and

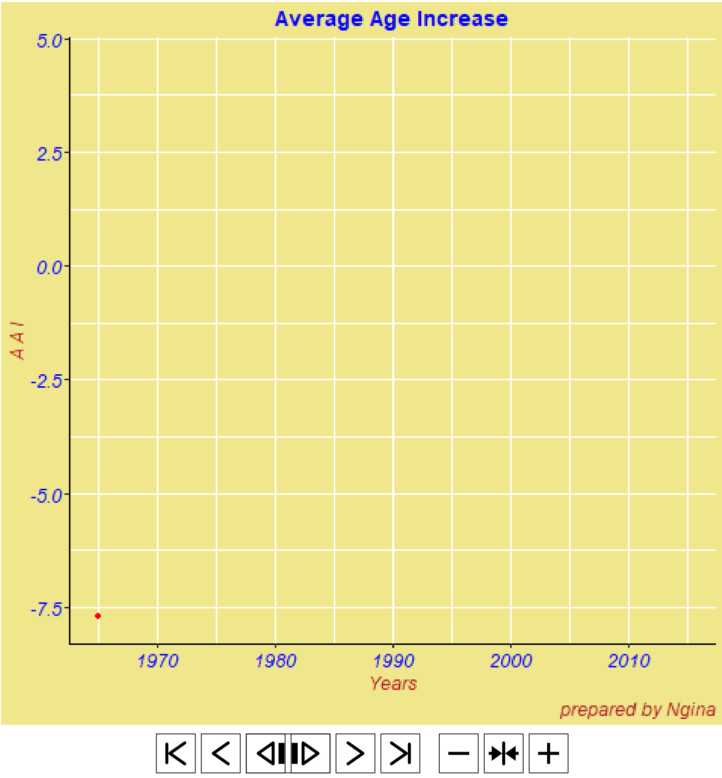

Figure 4.1: Summary of average age increase trend from 1965 to 2015.

1985. Population growth rate declined gradually between 1985 and 2000 then proceeded by an almost no change between 2000 and 2015.

Figure 4.3 indicates a gradual rise in life expectancy between 1965 and 1980. It then declined between 1985 and 1995 before resuming a gradual increase. Life expectancy in 1965 is lower than that of 2015.

Figure 4.4 indicates a flat trend line of dependency ratio between 1965 and 1980. The trend line then falls gradually to 2015.

Figure 4.5 shows a sharp increase in capital investment between 1965 and 1970. It then followed by a sharp decline between 1970 and 1975 before a rapid rise to 1980 before a gradual decline to 2000. A gradual rise is seen between 2000 and 2010 and a slight increase between 2010 and 2015.

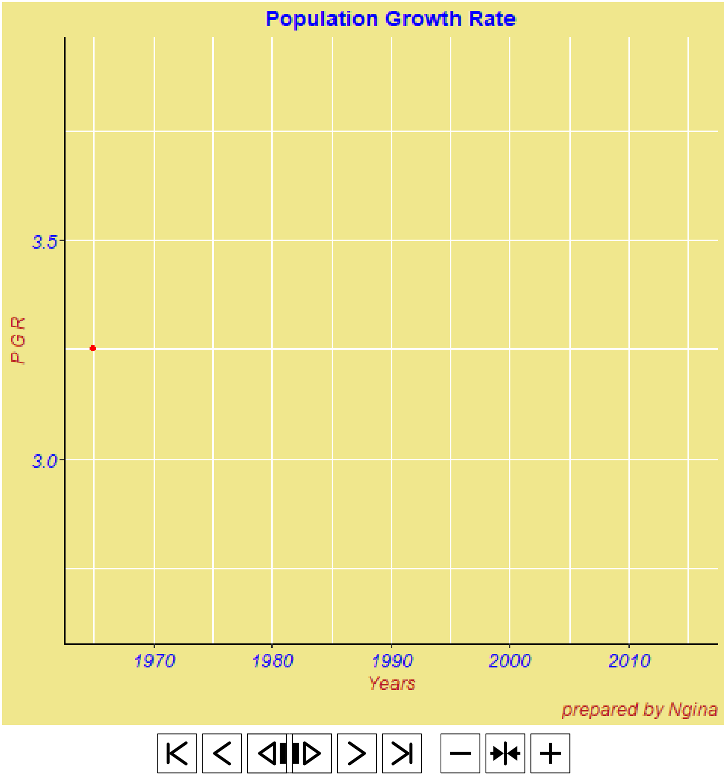

Figure 4.2: Summary of population growth rate trend from 1965 to 2015.

Descriptive Statistics

The study also sorts to explore the descriptive statistics of data collected. The descriptive statistics results are presented in Table 4.2 reveal that average age increase between 1965 and 2015 is 0.7282, population growth rate is 3.279, life expectancy is $\simeq$ 57 years, dependency ratio is 99.48% and capital investment is 20.9191% of GDP. Standard error of the mean is the standard deviation of the sampling distribution of the mean. Changes in standard error of the mean indicate indicate significant changes in data entries. Lower values of standard error of the mean shows no significant changes in data entries. Table 4.2 indicate that only population growth rate has a standard error mean value

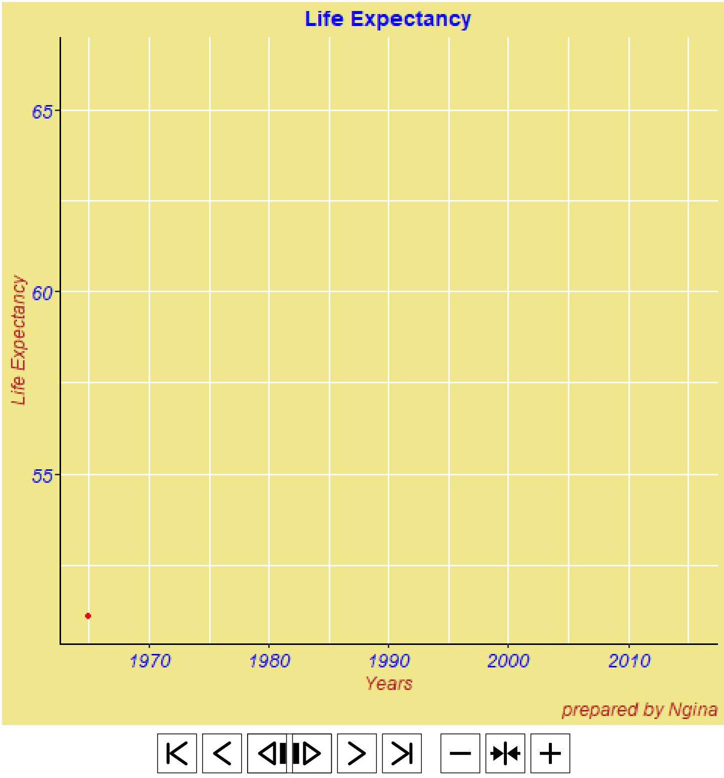

Figure 4.3: Summary of life expectancy trend from 1965 to 2015.

less than one: data is closely spread around the mean. The dependency ratio has the highest standard error mean, indicating the significant changes in data values.

Table 4.2: Descriptive statistics of demographic variables and investment data collected for the period between 1965 and 2015.

Variable	**Mean**	**Std. Error Mean**
AAI	0.7282	1.1313
PGR	3.2791	0.1413
LE	56.8909	1.4405
DR	99.4800	4.0069
CI	20.9191	1.0844

Source: Researcher

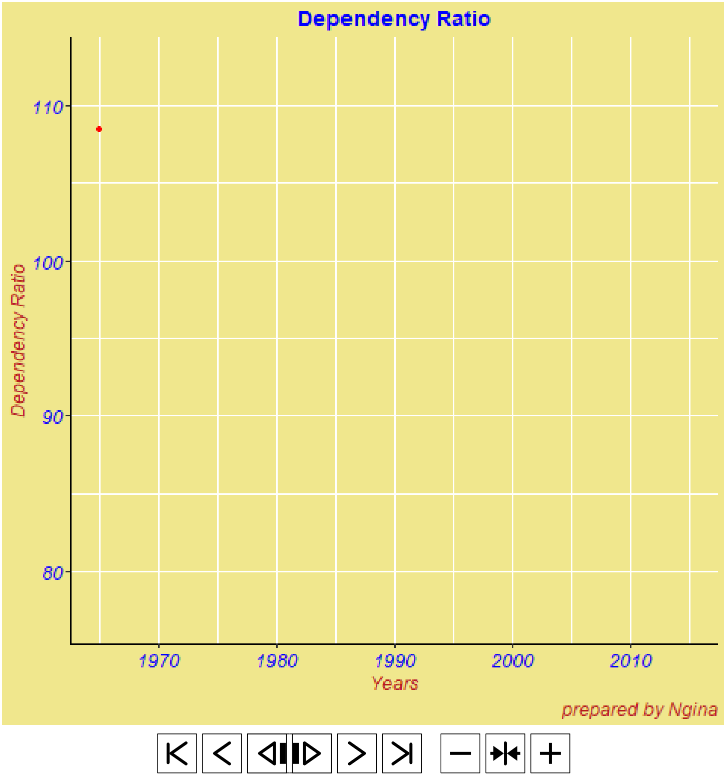

Figure 4.4: Summary of dependency ratio trend from 1965 to 2015.

Correlation Analysis

The study employs Pearson's correlation analysis to find the strength and direction of the linear relationship between dependent and independent variables. The higher the values, the stronger the relationship. The relationship can either be $+ve$ or $-ve$, and the values range from -1 to 1. However, the closer the values are to either -1 or 1 shows, the stronger the relationship. Significance level shows the statistically significant relationship between the independent variables (average age increase, population growth, life expectancy, and dependency ratio) and dependent variables (Capital investment)

Table 4.3 indicate that all the demographic variables have a positive

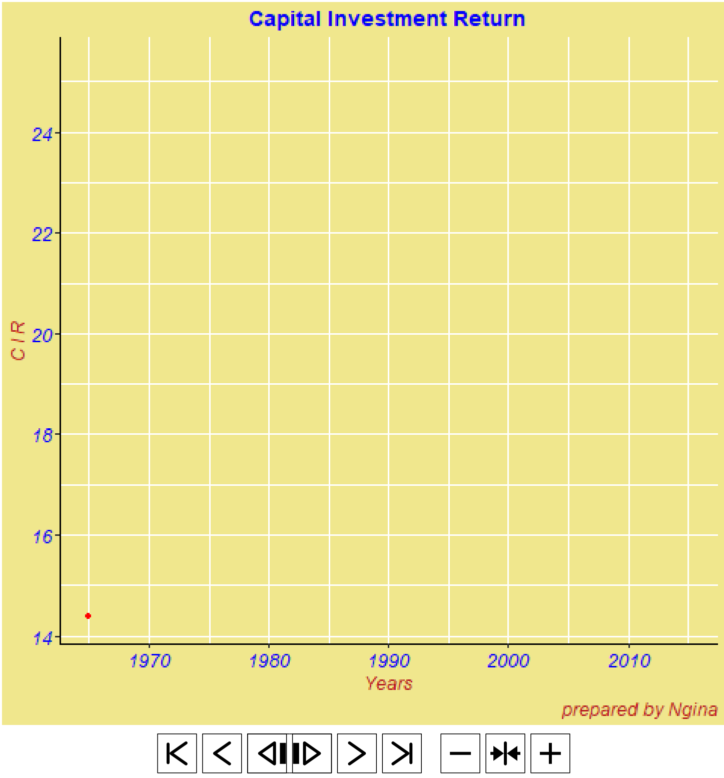

Figure 4.5: Summary of capital investment trend from 1965 to 2015.

Table 4.3: Pearson's correlation values between independent variables (average age, population growth rate, life expectancy and dependency ratio) and dependent variable (capital investment)

Item	CI	Significance
AAI	0.252	0.455
PGR	0.492	0.124
LE	0.305	0.362
DR	0.269	0.424

Source: Researcher

correlation with capital investment return. The population growth rate has the strongest positive correlation with capital investment. The average age increase has the weakest positive correlation with capital investment.

4.1.2 Regression Analysis

Regression analysis presents model summary, ANOVA and regression coefficients.

Model Summary

Model Summary for the modelling efficacy of demographic changes on and capital investment.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.832a	.693	.488	2.57398	.693	3.381	4	6	.089

a Predictors: (Constant), DR, LE, AAI, PGR

The model summary results give the strength of the relationship between the dependent variables and the model. R, which is equal to .832, is the multiple correlation coefficient. R shows the linear correlation between the observed and model-predicted values of the capital investment as the dependent variable. $0 \leq R \leq 1$ and large values are preferred since they indicate a strong relationship. R Square, which is equal to 0.693, is the coefficient of determination. It shows the variation of the model parameters. Adjusted R Square is a modified R Square statistic based on large parameters in the model. Change statistics are essential in the selection of the model. However, in this case, we only have one model; hence there use is insignificant.

ANOVA

The resulting ANOVA output is,

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	89.605	4	22.401	3.381	.089
	Residual	39.752	6	6.625		
	Total	129.357	10			

a Dependent Variable: CI

b Predictors: (Constant), DR, LE, AAI, PGR

The results above show the F value is 3.381 and using F-distribution table at $\alpha = 0.05$, $F_{0.05;4,6} = 4.5337$. Since the F critical is more than F statistics, hence the demographic variables are significant in modelling capital investment output. The p-value for 3.381 is 0.089 and since $\alpha = 0.05 < 0.089$, implying that the test statistic is not significant at that level.

4.1.3 Regression Coefficients

The regression analysis coefficients are summarized as, Coefficients for regression analysis

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-55.757	46.596		-1.197	.277
	AAI	1.101	.666	1.148	1.652	.150
	PGR	-8.078	15.690	-1.052	-.515	.625
	LE	.623	.460	.828	1.356	.224
	DR	.673	.718	2.485	.936	.385

a Dependent Variable: CI

Output above suggest that regression model equation of the form $Y = \beta + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4$ where Y is Capital Investment (CI), $\beta_i : i = 1, ..., 4$ are constants coefficient of regression analysis, $x_j : j = 1, ..., 4$ are independent variables, i.e., AAI, PGR, LE and DR respectively. Based on the output, regression equation can be constructed as,

$$Y = -55.757 + 1.101x_1 - 8.078x_2 + 0.623x_3 + 0.673x_4. \tag{4.1}$$

Equation (4.1)) suggests that average age, life expectancy, and dependency ratio increases capital investment while population growth rate decreases capital investment. The output also suggested that all the demographic changes variables are statistically insignificant predictor since coefficient $p - values = (.150.625, .224, 385) > 0.05$.

4.2 The Models

We use the analogy in Section 4.1.2 to satisfy the study objectives.

4.2.1 Average Age Increase

The model for average age increase and capital investment return is presented in Equation 3.1 as borrowed from the works of Poterba (2001) as,

$$\rho_{RCI} = \frac{\tilde{\Lambda}_{\psi}\tilde{\xi}}{\tilde{\mathcal{K}}}, \tag{4.2}$$

where ρ_{RCI} is the return on capital investment, $\tilde{\Lambda}_{\psi}$ average age increase, $\tilde{\xi}$ is the average saving rate of Kenya population and $\tilde{\mathcal{K}}$ is the average fixed supply of assets. Regression analysis test of capital investment and average age increasing assuming population growth rate, life expectancy and dependency ratio are constants is presented below. Thus, Equation (4.2) can be written as,

$$\rho_{RCI} = 0.241\tilde{\Lambda}_{\psi}, \tag{4.3}$$

suggesting that $\frac{\tilde{\xi}}{\tilde{\mathcal{K}}} = 0.241$.

Coefficients for regression analysis assuming other demographic variables are constant

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	20.743	1.129		18.374	.000
	AAI	.241	.309	.252	.781	.455

a Dependent Variable: CI

4.2.2 Population Growth

The model of population growth rate and capital investment can be estimated from Equation (3.3) assuming $b_t + b \log \tilde{\tau}_t \simeq 0$, hence,

$$\begin{aligned} \log \tilde{\mathcal{M}}_t &= p_t \log \tilde{\eta}_t, \\ \Longleftrightarrow e^{p_t} &= \frac{\tilde{\mathcal{M}}_t}{\tilde{\eta}_t}. \end{aligned} \tag{4.4}$$

where $\tilde{\mathcal{M}} \equiv CI$ is capital investment return , and $\tilde{\eta}$ is population growth rate. p_t is computed by

$$\begin{aligned} &\frac{CI_{average}}{PGR_{average}} = \frac{\tilde{\mathcal{M}}}{\tilde{\eta}}, \\ &\Longleftrightarrow \frac{20.919}{3.279} = e^{p_t}, \\ &\Longleftrightarrow 6.38 = e^{p_t}, \\ &\Longleftrightarrow \log 6.38 = p_t, \\ &\Longleftrightarrow p_t = 0.8. \end{aligned} \tag{4.5}$$

Thus, Equation (4.4) can be written as

$$\log \tilde{\mathcal{M}}_t = 0.8 \log \tilde{\eta}_t, \tag{4.6}$$

and is the model for estimating population growth rate, $\tilde{\eta}_t$, and capital investment return, $\tilde{\mathcal{M}}_t$.

4.2.3 Life Expectancy

Based on Equation (3.6), $V_t = m_t \eta_t \bar{X}_t P^3$ and P is analogous to life expectancy if $b = 1$. $m_t \eta_t = 0.996$ is total factor of productivity (Lederman *et al.*, 2017). Thus, $\bar{X}_t$, is the productivity or technology of use, can be computed as,

$$\begin{aligned} \bar{V} &= \left(0.996\bar{X}\right) P^3 \\ \iff \bar{X} &= \frac{\bar{V}}{0.996\bar{P}^3} \\ \iff \bar{X} &= \frac{20.919}{0.996 \times 56.89^3} \\ \iff \bar{X} &= 0.000114 \end{aligned} \tag{4.7}$$

Equation (4.7) can be used to suggest that a mathematical modelling equation for life expectancy and capital investment return is,

$$\begin{aligned} V_t =& 0.996 \times 0.000114 P^3, \\ =& 1.135 P^3 \times 10^{-4} \end{aligned} \tag{4.8}$$

where V_t is capital investment return, and P is life expectancy.

4.2.4 Dependency Ratio

We can summarize Equation (3.7) as,

$$
\begin{aligned}
&\varsigma - \varrho = \gimel\sigma, \\
&\iff (\varsigma - \varrho) \equiv DR, \\
&\gimel \equiv CI, \sigma \equiv \frac{DR}{CI}, \\
&\sigma = 4.755.
\end{aligned} \tag{4.9}
$$

where $\gimel$ is real interest rate, thus analogous to capital investment return, $\varsigma - \varrho$ wages earned less consumption and thus analogous to dependency ratio and σ is ratio. The findings of Equation (4.9) can be used to estimate model equation for dependency ratio and capital investment return as,

$$
\begin{aligned}
4.755CI &= DR \\
\Rightarrow CI &= 0.21DR
\end{aligned} \tag{4.10}
$$

Chapter 5

Discussions, Conclusions and Recommendations

5.1 Discussion

Demographic factors have been linked to influencing of the level of investment behaviors by many scholars (Asongu, 2013, Charles & Kasilingam, 2013, Fang & Wang, 2005, Jeon *et al.*, 2010, Lewellen *et al.*, 1977, Mittal & Vyas, 2008, Sakbani, 2011, Seetharaman *et al.*, 2017). However, in this study the focus was estimating, modeling, determining a mathematical relationship between four significant demographic variables and their influence on capital investment in Kenya. Thus, the study sort to estimate a mathematical model explaining the relationship between average age increase and capital investment returns, model population growth rate, and capital investment returns, determine the relationship between life expectancy and capital investment returns and model dependency ratio and capital investments in Kenya. The study used secondary data in order to fulfill its objectives.

5.1.1 Average growth rate and Capital Investment

Age is pivotal in investment decision making and affects the level of confidence of investors. Therefore, it is expected that as average age increases, so is the capital investment returns (see Figures 4.1 and 4.5). Agarwal *et al.* (2009), Ansari (2019) have also supported this observation and noted that financial decision making increases with age. Looking closely at the Figures 4.1 and 4.5 capital investment return increases as age increases. Further analysis shows that between 1965 and 1970, the average age increases rapidly, so is capital investment.

Correlation analysis shows that the average age increase has a positive correlation with capital investment return. Although the relationship is not statistically significant, the strength of the relationship is significant. This observation is supported by existing studies that have shown that there is a strong positive relationship between average age increase and capital investment return (Agarwal *et al.*, 2009, Ansari, 2019, Geetha & Ramesh, 2012, Poterba, 2001).

Regression analysis gives $R = 0.832$, which indicates a strong linear correlation between average age increase and capital investment return. The coefficients of the regression analysis show a positive relationship. If other demographic values are assumed constant, the average age increase indicated a stronger and positive linear relationship with capital investment return. It is also worth noting that if only average age increase is assumed to influence capital investment return, then the coefficient of regression analysis is positive and statistically significant. All these observations are summarized in Equation (4.3), estimating a mathematical model explaining the relationship between average age increase and capital investment. The estimated equation also suggests that capital investment return would increase as average age increases.

5.1.2 Population Growth and Capital Investment

As argued by Bidisha *et al.* (2020), population structure is significant in investment decisions. Therefore, we would expect a complex relationship between population growth and capital investment returns. For instance, looking at the graphical representation of data in Figures 4.2 and 4.5 between 1965 and 1985, the population growth rate increase gradually while capital investment return presents a rise and fall within the same period. However, throughout the entire period of the study, the population growth rate reduces gradually while capital investment return increases.

Correlation analysis indicates that population growth has a strong positive relationship with capital investment return. The strength of a relationship is statistically insignificant. These observations are similar to that of Simplice *et al.* (2011) who noted through Equation (2.8) that human capital improves capital investment by lowering labour. Thus, making a similar observation to that of Asongu (2015). Regression analysis gives a negative coefficient, suggesting that when other demographic variables are considered, then the population growth rate decreases capital investment return.

The model of population growth rate and capital investment returns depicts a constant relationship composed of logarithmic relations. However, the Equation (4.6) a positive coefficient of a logarithmic relationship between capital investment return and population growth rate.

5.1.3 Life Expectancy and Capital Investment

Individuals tend to invest more when they are perceived to live longer. Higher life expectancy is indicative of higher capital investment return. The graphical representation of data in Figures 4.3 and 4.5 shows that life expectancy increases between 1965 and 1980 while capital investment return increases between 1965 and 1970 then decrease between 1970 and 1975 and increase. However, the overall observation shows that life expectancy has gradual increment and decrements wile capital investment exhibit a similar pattern. Correlation analysis shows that life expectancy has a positive linear relationship with capital investment return, and the relationship is statistically insignificant. This observation is similar to that noted by the world bank in Costa Rica and Sierra Leone, as pointed out by Azomahou & Mishra (2008), Bhargava *et al.* (2001), Chakraborty (2004). Regression analysis gives a positive coefficient, which also suggests that life expectancy has a positive effect on capital investment returns. These findings were similar to that of Brander & Dowrick (1994), who noted that life expectancy increases as capital investment returns.

The model Equation (4.8) shows a complex positive relationship between life expectancy and capital investment return. The model suggestions are similar to that of Boersch-Supan & Winter (2001), Kalemli-Ozcan *et al.*

(2000) who found that the relationship between life expectancy and capital investment is sophisticated.

5.1.4 Dependency Ratio and Capital Investment

The dependency ratio affects savings; hence endogenously affect capital investment. The relationship between dependency ratio and capital investment returns are based on a combination of many demographic variables such as population growth rate and working-age population ratio. Graphical representation of data shows that the dependency ratio gradually decreases while capital investment increases and decreases over the study period. Correlation analysis shows that the dependency ratio has a positive relationship with capital investment return, and the relationship is statistically insignificant. Regression analysis indicates a similar observation. These findings are similar to those presented in the literature, such as Krueger & Ludwig (2007), Li *et al.* (2007) noted that the relationship between dependency ratio and capital investment is region specif, hence non-conclusive. However, the studies have noted that in sub-Saharan Africa, the dependency ratio through savings negatively affects the capital investment return. The model equation (Equation (4.10)) suggests that the dependency ratio positively influences capital investment return.

5.2 Conclusion and Recommendations

The study established the effectiveness of demographic changes in capital investment in Kenya. The study specifically sorts to estimate mathematical model explaining the relationship between average age increase and capital investment in Kenya, model population growth rate and capital investment returns in Kenya, determine the relationship between life expectancy and capital investment in Kenya and model dependency ratio and capital investment in Kenya. Through analysis of secondary data, average age increase, population growth rate, life expectancy, and dependency ratio have a positive correlation with capital investment. Regression analysis indicated that all demographic variables except the population growth rate positively affect capital investment returns. The findings of the study established that Equations (4.3), (4.6), (4.8), and (4.10) can be used to explain the mathematical relationship between average age increase, population growth rate, life expectancy, and dependency ratio respectively. Future work on the topic needs to expand the study to other countries in order to have a more comprehensive understanding of the relationship. Further analysis should also be adjusted to accommodate all demographic variables.

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