University of Nairobi

Masters Thesis in Actuarial Science

Modeling Interest Rate on Economic growth of Kenya between 1970 and 2018

Research Report in Mathematics, 2020

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Submitted to the School of Mathematics in partial fulfillment for a degree in Master of Science in Actuarial Science

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 beloved parents, Haron Nyabuto and Esther Mwango, who have been my source of strength and inspiration when I thought of giving up and have continually provided their emotional, spiritual and financial support. To my siblings Emily, Naomi, Livingstone and Sammy, for their ample time and support accorded to me during the development of this research thesis.

Acknowledgment

I am indebted to acknowledge the Almighty God for His grace, favour and strength throughout the process and completion of this thesis. I would like to express my sincere gratitude to my Supervisor Prof P. Weke who gave me constant support during the preparation of this research work. To all other lecturers in the department of mathematics, University of Nairobi, my classmates, specifically Ann Maureen Wangui Ngina, and my colleagues at work place - Liaison Group (IB) Limited, for their moral support and encouragement. Lastly but not the least, I would like to acknowledge my family and more so my parents Haron Nyabuto and Esther Mwango for their support both morally and financially throughout the time of writing this thesis.

Maureen N. Nyabonyi

University of Nairobi, 2020

Abstract

The high-interest rate has been a problem in Sub-Saharan Africa, specifically Kenya, for a long time. The high-interest rates have prevented the growth of companies since they shun away from borrowing capital to grow their business. Most governments have used interest rate capping as a ceiling tool to regulate and control the excessive interest rate by financial institutions. During interest rate capping periods, the Kenyan government controls the official interest rate for banks operating within their borders, hence reducing banks' appetite to deposit, which may reduce money in circulation, thus reducing demand and supply. Developing countries, like Kenya, tend to have a negative real interest rate resulting from administrative controls on nominal interest rates and burdensome regulations of their financial markets. Existing studies that have indirectly linked interest rates and economic growth are from Latin America and Asia. Furthermore, existing studies have adopted inappropriate mathematical tools to relate to interest rates and economic growth.

The study sort to the model interest rate on the economic growth of Kenya between 1970 and 2018. The study specifically 1) Model interest rate capping and economic growth of Kenya. 2) Model mathematical relationship between the lending interest rate and economic growth of Kenya. 3) Estimate the mathematical relationship between the deposit interest rate and economic growth of Kenya and 4) Approximate mathematical relationship between the real interest rate and economic growth of Kenya.

Data analysis based on SPSS, Matlab, Excel and R for secondary data central bank of Kenya website indicated that only the real interest rate has a positive correlation with economic growth. Regression analysis also suggests that only the real interest rate positively affects economic growth. Descriptive statistics indicated that the capping interest rate has the highest standard error mean (1.1536), and economic growth had the least standard error mean value (0.5936). The models formulated also show capping interest rates and lending interest rates have negative relationships with economic growth. The relationship between the deposit interest rate and economic growth is based on regression equation and deposit interest rate is estimated based on an optimization problem. The optimization problem solution indicates that the optimal deposit interest rate is 0.06039. The real interest rate model formulated also shows that a positive relationship with economic growth. The study concludes that the interest rate is significant in economic growth. The study suggests a future segmented short- and long-term effects of interest rate indicators on economic growth.

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List of Abbreviations and Acronyms

SMEs	Small Medium Enterprises
CBK	Central Bank of Kenya

Chapter 1

Introduction

1.1 Background Information

Economists have studied the functional role played by the interest rate on economic growth for a long time now (Kosse, 2002; Tajudeen et al., 2017). However, the role of interest rate indicators has remained a complex phenomenon in many countries. Therefore, researchers have continued to develop and test theoretical and mathematical models to help understand the relationship between interest rates indicators and economic growth (Tajudeen et al., 2017).

Despite technical indicators linking interest rates to economic growth, developing economies, such as Kenya, researchers hardly exhibit this relationship. The high-interest rate has been a problem in Sub-saharan Africa, specifically Kenya, for a long time: it prevents the growth of companies since they shun away from borrowing capital to grow their business (Mathenge, 2018; Tajudeen et al., 2017). High-interest rates escalated in the 2000s' and most of the privately owned firms have closed or relocated to neighboring countries where they can afford loans at affordable interest rates (Cummings and Guo, 2020). Moreover, newly formed companies also closed due to lack of funds to either expand or service their operations: since they cannot afford loans and rely on their limited capital. To moderate a high-interest rate and promote the growth of SMEs, the government has periodically reviewed the interest rate. However, there has is no established mathematical relationship between the interest rate and economic growth in Kenya.

Most governments have used interest rate capping as a ceiling tool to regulate and control the excessive interest rate by financial institutions (Mathenge, 2018). Interest rate capping, therefore, is purposefully meant for consumer protection. While it is beneficial to clients, it can reduce the profits of financial institutions and hence render them profitless (Kibobo, 2017). Interest rate regulation, as explained by most scholars, has dire economic consequences on the clients more than financial institutions(Bean et al., 2015; Kibobo, 2017; Kimunge, 2017).

The interest rate may affect economic growth by either reducing or increasing financial institutions lending behaviors as the maximum interest, which they often impose to mitigate the moral hazard (Thuo, 2019). The financial institution will counteract this by having to invest more in systems to help identify the right customers who are creditworthy (Kibobo, 2017). The institutions will hence only lend to only those customers with creditworthiness leaving out the majority of the population. Other banks responded to lower interest rates by maximizing their interest spread (the difference between interest on loans and deposits or savings) to increase their profit margin. However, interest rate regulation leads to reduced interest spread, and consequences felt by Small Medium Enterprises (SMEs) and other borrowers who are deemed too high-risk (Mathenge, 2018; Miller, 2013). In order to increase profit margins, financial institutions have also resorted to lending to multinational companies. This has reduced domestic credit (loans offered to customers within Kenya) (Kimunge, 2017).

1.1.1 Interest rate capping and economic growth

Interest rate capping is limiting how high the interest rate on a loan or deposit or savings may rise. Capping is a regulatory measure used by governments of a given country to protect its citizens from exploitation by commercial banks (Odhiambo, 2019). The interest rate cap tends to fluctuate without exceeding the government-set limit. Many countries introduce interest rate capping with mixed results on economic growth (Munguti, 2015; Odhiambo, 2019). Countries introduce interest capping to enhance financial inclusivity (aim to foster financial literacy level, bring transparency) (Maimbo and Henriquez, 2014; Odhiambo, 2019). Interest rate capping tends to impact the economy positively, enhance productivity, and reduce poverty by making loans affordable for the creation of jobs through SMEs (Bekaert et al., 2005; Odhiambo, 2019). Interest rate capping can also serve to cool down political and economic pressures from business and political class in a country (Bekaert et al., 2005; Odhiambo, 2019). Interest rate capping results to mix results in the economy such as the inclusion of economically disenfranchised segments of the population; the shift in lending where banks prefer to lend to the government and large corporations than to small borrowers who are credit unworthy (Kosse, 2002; Munguti, 2015; Odhiambo, 2019; Tajudeen et al., 2017).

1.1.2 Lending interest rate and economic growth

Most studies explored the relationship between the lending interest rate and the financial performance of the banks. Few studies show that lending interest rate affects economic growth (Ngugi, 2001; Were and Wambua, 2013). For instance, Ngugi (2001) studied factors that affect the lending interest rate for the banking system in Kenya. The study compared lending interest rate data and those of economic before and after interest rate capping. The study findings noted that the lending interest rate has negative economic growth in terms of banking performance. The study did not include other interest rate variables.

1.1.3 Deposit interest rate and economic growth

During interest rate capping periods, the Kenyan government controls the official interest rate for banks operating within their borders (Chang, 2019; Irungu, 2013). This may reduce banks' appetite to deposit, which may reduce money in circulation and hence reducing demand and supply (Chang, 2019; Ganatra, 2016). Ganatra (2016) argues that during interest regulation, financial institution promotes saving and providing a large pool of finance for SMEs who are the drivers of the economy. (Irungu, 2013) made a similar assertion and noted that the availability of savings provides enough capital for borrowers who may need to finance and expand their SMEs. Consequently, more jobs are created, which may expand the economy yielding economic growth.

1.1.4 Real interest rate and economic growth

A real interest rate is an interest rate that has been adjusted to remove the effects of inflation. Real interest rate helps an investor to know the real cost of funds to borrow (Lugo et al., 2008). The real interest rate fosters financial liberation, which promotes savings, investment, and growth of the economy in developing countries (Lugo et al., 2008). Developing countries have a tendency to have a negative real interest rate resulting from administrative controls on nominal interest rates and heavy regulations of their financial markets. Consequently, developing countries have a net positive effect on private investment (Mendoza, 2002).

The negative relationship between investment and interest rates favors developing economies and hence encourages savings leading to the availability of funds for development and investment (Molho, 1986). Private investment in developing countries can be nonlinear in credit availability, and this causes asymmetric information problems resulting in a decrease in sensitivity of private investment on credit availability (Lugo et al., 2008). Credit availability for private investment adversely affects economic growth (Korkmaz, 2015; Lidiema, 2018).

1.2 Statement of the Problem

The majority of the studies linking interest rate and economic growth are mostly from Latin America and Asia (Tajudeen et al., 2017). The current existing studies on the interest rate effect on economic growth base their research on some African countries (Charlier and Oguie, 2002; Fowowe, 2008; Obamuyi, 2009; Odhiambo, 2009; Oshikoya, 1992). The existing studies on interest rate extensively related interest rate reforms to economic growth indirectly. Such a move is a major limitation since the interest rate affects economic growth through financial deepening and savings.

The existing studies have used bivariate and Granger causality tests to examine the relationship between interest rates and economic growth (Asteriou and Hall, 2007; Tajudeen et al., 2017). These techniques are adequate but subjectively inappropriate considering the mathematical relationship between interest rate and economic growth may be subjective in pro and pre-interest rate regulation era, and thus, there is a need to use a mix of various techniques. The existing studies have also used traditional, neoclassical, exogenous, endogenous, and institutional growth theory of growth. The present studies need to investigate the model risk and uncertainties to allow a holistic model of interest rate on economic growth.

1.3 Objectives of the Study

1.3.1 Overall Objectives

The overall objective of the study is to model interest rate on economic growth of Kenya between 1970 and 2018.

1.3.2 Specific Objectives

The specific objectives are,

1. Model interest rate capping and economic growth of Kenya.

2. Model mathematical relationship between lending interest rate and economic growth of Kenya.

3. Estimate mathematical relationship between deposit interest rate and economic growth of Kenya.

4. Approximate mathematical relationship between real interest rate and economic growth of Kenya.

1.4 Significance of the Study

The study findings will be of great benefit to the government, scholars, and the general public. The government, through the Ministry of Finance and Planning, will benefit from the recent information, which is vital in policy formulation aimed at regulating interest rates. The policies will also be aimed at regulating interest rates to foster investments, boost economic growth, and reduce poverty. The study will provide more insights on the topic on the Interest rate and will thus serve as reference material to other scholars interested in this subject. The government of Kenya will also benefit as they will be able to get a vital reference before making decisions about interest rate regulations.

1.5 Scope of the Study

The study focuses on modeling interest rates on the economic growth of Kenya between 1970 and 2018. The research will focus on data between 1970 and 2018. The data collected will focus on interest rate capping, interest rate, lending, and deposit interest rate and real interest rate. Data analysis will exploit only relevant mathematical tools and concepts.

Chapter 2

Literature Review

2.1 Introduction

The financial sector of Kenya has evolved from direct control in the 1970s to full liberalization in the 1990s, leading to an impact on market-determined interest rates (CBK, 2018). The Banking (Amendment) Act of 2016 sets a maximum lending rate at no more than 4% above the Central Bank base rate. The act has also set a minimum interest rate granted on deposit held in an interest-earning account to at least 70% of the same rate. Interest rate control has reprobate monetary policy outcomes. However, the extent of this perverse outcome has not been modelled, especially in the economy of Kenya. This rest of the sections in this chapter covers the literature and theoretical reviews on capping interest rates, lending interest rate, deposit interest rate, and real interest rate and their impact on economic growth.

2.2 Interest Rate Capping and Economic Growth

The interest rate significantly affects savings and investment (Mushtaq and Siddiqui, 2016). A higher interest rate promotes more savings discouraging investment as the cost of capital increases, which reduces investment in the economy. However, the extent of this effect has not been modeled in Kenya despite the existence of many empirical reviews (Mutemi and Makori, 2019; Ng'ang'a, 2017). Therefore, the paper models the mathematical relationship between interest rate capping and economic growth of Kenya as one of the specific objectives.

Classical economist states that saving is a function of interest rate; therefore, when saving is high, individuals save more and consume less (Mushtaq and Siddiqui, 2016). Thus, focusing on utility maximization function based on substitution and income effect. High interest would lead to a decrease in current consumption. Higher interest rates translate to high borrowing costs, and hence people tend to save more to fulfill their future needs. Thus, in theory, the interest rate has a positive relationship with savings. According to Muhammad et al. (2013) investment is a function of interest rate and income, that is,

$$\gamma = f\Bigg(- \tau + \alpha\xi \Bigg), \tag{2.1}$$

where γ is an investment, τ is the interest rate, ξ is income, and α is a constant coefficient of income. Equation (2.1) shows that the interest rate increases the cost of borrowing, thus reducing investment.

Economic growth is a factor of investment, and therefore, if interest ceiling or capping increases investments, so does it promote economic growth. Economic growth is realized when there is more investment in a country, which is not realistic in the event of a higher cost of borrowing. To enable economic growth by regulating the cost of borrowing, many governments (including the Kenya government) have continued to participate in the operations of the financial market. The inclusion of government in financial operation has hampered the free equilibrium of demand and supply, which has affected the determination of equilibrium quantity and prices (Ochieng et al., 2018). According to Helms and Reille (2004); Miller (2013), too low or too high-interest rate caps are not beneficial, especially when fees and commissions are not covered.

Studies have shown that in the 21^{st} century, many developing countries have continued to liberalize their financial policies (Batuo et al., 2018; Bumann et al., 2013; Levine, 2001; Naveed and Mahmood, 2019; Trabelsi and Cherif, 2017). This has increased accessibility of financial markets thus stimulating economic growth. Jayadev et al. (2018) also indicated that financial liberalization as a tool improves small scale enterprises' access to funds. However, the financial crisis of 2008 paved the way for debate on interest rate controls to protect consumers from exploitation from financial institutions.

Scholars have also argued that interest caps solely serve consumer protection and is guarantees access to credit at reasonable interest rates. On the other hand, interest caps limits credits to low or impairment consumer and have mixed results (Ferrari et al., 2018). Kavwele et al. (2018); Madeira (2019) noted that financial liberalization does not affect the financial depth of most developing countries such as South Korea. However, the banking industry in Kenya amid interest rate capping has witnessed a steady increase in micro-lending accompanied by loss of jobs (Kiai and Kiambati, 2019).

2.3 Lending Interest Rate and Economic Growth

Caps on lending rates have been used by governments to increase access to credit to stimulate economic growth (Ferrari et al., 2018; Joaquim and Sandri, 2019). Models of lending interest rates on economic growth are based on limited credit access on investment and productivity. The existing models, as will be presented here, have been used extensively by many scholars to analyze various policy measures on financial friction and their effects on economic development (Buera and Shin, 2013; Joaquim and Sandri, 2019). For instance, Song et al. (2011) noted that among the many interest rate policies adopted in China to increase access to credit, the lending rate was the most significant. Itskhoki and Moll (2019) proved that developing strong lending rate policies help boost profits, thus allowing investors to increase investment. The existing literature does not fully exploit the effect of lending rate ceiling or control on the economic growth of developing countries. Safavian and Zia (2018) established that introduction of interest rates caps in Kenya in 2016 made financial institution shift their lending rates, that is, from small and medium firms to 'safer' corporate borrowers.

If we begin with credit policy models, as described by Joaquim and Sandri (2019), and considering single lending on all loans capped. The model described below price-out riskier bank managers and reduced the average cost of finance for credit. This observation is in tandem with the establishment noted by Cuesta and Sepulveda (2019). However, for the case of the Kenyan economy, lending rate cap increases capital accumulation since the average cost of finance is reduced.

If the effect of interest rate cap $\bar{l}$ for all loans types r must be made be representative bank to have $l^{\iota} \leq \bar{l}$. If the interest rate of for type r is defined as,

$$l^{z,*}(r,m) \equiv (1+s)\left[l + m\frac{f(p)}{b}\right] \tag{2.2}$$

where s is riskiness of the market in terms of loans, p is productivity of the economy, $l^{z,*}(r,m)$ interest rate consistent with the end of period wealth $\beth^{z,*}(r,m)$ which is defined based on optimization problem as (Joaquim and Sandri, 2019),

$$\begin{aligned} \beth^{z,*}(r,m) &= (1-m)\beth^{h}\left(l^{\daleth\gimel}(s), z|r\right) + m\hat{\beth}^{h}(l, z|r) \\ &= (1-m)f(r) + \hat{\beth}^{h}(l, z|r) \end{aligned} \tag{2.3a}$$

subject to bank profits by each loan offered

$$\beth^{d}(\beth^{z,*}(r,m)) = mf(r) \tag{2.3b}$$

$$f(r) = x^{-1}\left[\beth^{h}\left(l^{\daleth\gimel}(s), z|r\right) - \hat{\beth}^{h}(l, z|r)\right] \tag{2.3c}$$

Equations (2.3a)-(2.3c) are based on the Cournot model (where competative firms choose quantities to produce independently and simultaneousl). In the Cournot model, $m = \frac{1}{D+1}$ where D is number of financial institutions. Equations (2.3a)-(2.3c) through Equation (2.2) can be solved in 3 cases, that is,

1. $l^{z,*} \leq \bar{l}$: when the bank charges the same interest rate

2. $l^{z,*} \geq \bar{l}$: when the bank offers loan at rate $\bar{l}$ from where it makes it's profit.

3. Bank to make profit lending at rate $\bar{l}$, such that,

$$\frac{1}{1+s}\bar{l} - l \geq 0 \Leftrightarrow s \leq \frac{\bar{l}}{l} - 1 \equiv \bar{s} \tag{2.4}$$

Equation (2.4) suggests that if the bank has to rely on lending rate to make profit, then it has to adopt cutt-off strategy. Therefore, if financial institution manager have $s > \bar{s}$, then the bank fail to extend loan limit. In that case, the bank will be opt to lend at the unconstrained rate or a minimum of $\bar{l}$ and $l^{z,*}(r,m)$[1]. The scenario can be different depending on the manager if other managers can receive interest rate cap $s^{all}\left(p,m,\bar{l}\right)$ such that,

$$\begin{aligned}\left(1+s^{all}\left(p,m,\bar{l}\right)\right)\left[l+m\frac{f(p)}{b}\right] \\ &=\bar{l} \\ &\Rightarrow s^{all}\left(p,m,\bar{l}\right) \\ &=\frac{\bar{l}}{l+m\frac{f(p)}{b}}-1.\end{aligned} \tag{2.5}$$

If $s \in \left[s^{all}\left(p,m,\bar{s}\right),\bar{s}\right]$ for productivity p, thus, the loan made to (p,s) is constrained and the interest rate on the loan is $\bar{l}$. Therefore, in order to promote economy growth, government policies needs to boost economic productivity.

Several studies have presented the effect of lending interest rates on economic growth. A study by Bett (2013) exploited the importance of lending interest rates on the profitability of Saccos' in Kenya. Mutinda (2014) studied the effect of lending interest rates on economic growth in Kenya. Bett (2013); Mutinda (2014) established that there is a negative relationship between the interest rate and economic growth. Mutinda (2014) study recommended a need for a strong policy

[1] If the interest rate is capped, then banks would charge a minimum of charge, $l^{all}(r,m)=\min\{\bar{l},l^{z,*}(r,m)\}$, that is, provide loan iff $s \le \bar{s} \equiv \frac{\bar{l}}{l}-1$, otherwise no loan is provided if $s > \bar{s}$

framework to regulate lending interest rates.

He et al. (2014) noted that the effect of the lending rate on economic growth is ambiguous and depends on the ability of the banking industry to harness the competition arising from the bond markets. The lending rate is market-determined despite their levels and movements constrained by regulated deposits. This is because the banking sector dominates financial mediation; thus, the lending rate ceiling helps anchor the whole interest rate system (He and Wang, 2012, 2013). Therefore, the regional banking lending rate varies significantly for changes in monetary policy and deposit rate.

2.4 Deposit Interest Rate and Economic Growth

In many countries in the world, the deposit interest rate is prohibited and only allowed when paying interest on demand deposits (Eichberger and Harper, 1989). Deregulation of financial markets in the 1980s around the world resulted in the ceiling of deposit interest rates, which are currently abolished or substantially relaxed. The ceiling of deposit interest rate was to prevent destructive cut-throat competition among banks, thus promoting investment in riskier assets, which served to reduce the chances of a banking crisis (Gichuki et al., 2019; Mbua, 2017). The ceiling of deposit interest rate has therefore been seen as a capture strategy used by the Central Bank of Kenya (CBK) to reduce competition for deposit. The extent of influence of deposit interest rate on the Kenyan economy has neither been evaluated mathematically nor modeled. Therefore, in this paper, we model the mathematical relationship between the deposit interest rate and economic growth of Kenya as one of the specific objectives.

A rise in the deposit interest rate is a sign of the direction of interest rate (Hutchison and Pennacchi, 1996). It gives strong assumptions that depend on the first-order effect of the direction of the economy. If for every shilling drawn into time deposits, the banks will require a rise of χ_d, a disposable fund of $1 - \chi_d$ cents and demand for net free would rise by $\eta_d(1 - \chi_d)$ cents where η_d can be in both directions (±) and is the fraction of disposable funds assigned to net free reserves (Cottarelli et al., 1986; Mojon et al., 1998; Tobin, 1970). If we assumed that t cents for every new fund of time deposit is from demand deposit, and $1 - t$ is from assert outside banks, then the reduction in demand deposits lowers bank demand for reserves by

$$t\left[\chi_T + \eta_T(1 - \chi_T)\right] \tag{2.6}$$

Further assuming that the financial institution body control such as CBK or Fed holds the supply of unborrowed reserve constant, the net increment in excess demand for reserve based on Equation (2.6) is:

$$\chi_d - t\chi_T + \eta\,(1 - \chi_d) - \eta_T\,(1 - \chi_T)\,t \tag{2.7}$$

For large banks, Equation (2.7) will be positive, thus suggesting deflationary or inflationary counter-effective measures. Tobin (1970) established that equilibrium value of $t = .32$, that is, if $t < .32$ then Equation (2.7) have deflationary while $t > .32$ have inflationary impact on the economy. Gramlich et al. (1970) established that the likelihood of fluctuations of interest rates drives $t \simeq .37$, which is too high and does not allow for substitution into time deposits, loans and savings. t value for saving deposit is lowered by around 50% which encourages increase in ceiling deposit interest rate. According to Gramlich et al. (1970), a third of funds deposited into commercial banks due to increasing interest rates come from a savings account. A rise in deposit interest rate ceiling might restrict withdrawal and deposits. Commercial bank's shift in interest rate ceiling originated from demand deposits, and financial regulatory bodies would have to raise savings reserve requirements and time deposits. Arise in deposit interest rate induces swaps of assets between banks and the public, which invert as economic situation reverses (Sobrun and Turner, 2015).

Based on the the above theoretical review, the monetary impact of deposit interest rate with economic growth can be summarized based on simple model via Equation (2.7). If the vector of interest rate $\hat{\tau}$ includes the discount rate τ_D, bills τ_B, loans τ_L, capital τ_K and time deposit χ_D. If government debt is totaled as G and Γ is the in the form of non-borrowed reserve, then $G - \Gamma$ is the interest-bearing bills. Financial policy is therefore expansionary if it lowers τ_K, deflationary if τ_K is raised and neural if it leaves it unchanged. We can present the four balanced equations Equation (2.8)-(2.11) as,

$$\left[\chi_T + \eta_T(\hat{\tau})(1 - \chi_T)\right]T(\hat{\tau}) + \left[\chi_D + \eta_D(\hat{\tau})(1 - \chi_D)\right]D(\hat{\tau}) = \Gamma, \tag{2.8}$$

where $T(\hat{\tau})$ and $D(\hat{\tau})$ are public demand for demand deposits and time deposits respectively; χ_T and χ_T are already defined in Equation (2.7) and Equation (2.6). Once Equation (2.8) is met, then banks can dispose $(1 - \chi_D)T$ and $(1 - \chi_T)D$; $\eta_D(\hat{\tau})$ $\eta_T(\hat{\tau})$ are ± fractions of the disposable net free reserve fund held by the financial regulator.

$$\mu_T(\hat{\tau})(1 - \chi_T)T(\hat{\tau}) + \mu_D(\hat{\tau})(1 - \chi_D)D(\hat{\tau}) + \Omega(\hat{\tau}) = G - \Gamma \tag{2.9}$$

where $\mu_T(\hat{\tau})$ and $\mu_D(\hat{\tau})$ are fractions of disposable banks choose to hold in τ_B, that is, bills and $\Omega(\hat{\tau})$ is the public demand for bills.

$$\ell_T(\hat{\tau})(1-\chi_T)T(\hat{\tau}) + \ell_D(1-\chi_D)D(\hat{\tau}) + \Phi(\hat{\tau}) = 0 \tag{2.10}$$

where $\Phi(\hat{\tau})$ is loans. Equation 2.10 must equate to zero since banks liabilities and assert must balance for any interest vectors, that is $\eta_T+\mu_T+\ell_T = 1 = \eta_D+\mu_D+\ell_D$. Capital τ_C is given by,

$$\Lambda(\hat{\tau}) = \Pi \tag{2.11}$$

Summing Equations (2.8)-(2.11) we obtain,

$$T(\hat{\tau}) + D(\hat{\tau}) + \Omega(\hat{\tau}) + \Phi(\hat{\tau}) + \Lambda(\hat{\tau}) = G + \Pi \tag{2.12}$$

Equation (2.12) is an identity equation and is shown for any vector of interest rates; the public only allocates all their wealth. This suggests that interest rates are deterministic of financial market equilibrium. However, since the government has played a significant role in terms of G, its influence cannot be ignored. Thus, the ceiling is inevitable if consumer protection is mandatory.

The global financial crisis of 2008, which forced many governments into certain debt G (see Equation (2.12)), has rejuvenated evaluating the impact of some of the financial reforms. Scholars have attempted to find a relationship between the reduced deposit interest rate and economic growth (Moyo and Le Roux, 2018). Preliminary findings based on the pioneers of the financial liberalization hypothesis have shown that financial reforms boost economic growth through the promotion of savings and investment (Chukwuma, 2019). Recent studies on interest rates on savings and economic growth are inconclusive.

2.5 Real Interest Rate and Economic Growth

The interest rate is the cost of credit in the economy, which is the yearly price charged by a lender to a borrower to obtain a loan (Mutinda, 2014). The real interest rate is an interest rate modified based on the inflation (Mutinda, 2014). The lower the real interest rate, the lower the investing cost. Therefore, low-interest rate stimulates the economy. Lower real interest rate spurs spending. Higher spending lowers investment, thus hindering economic growth.

Interest rate modeling has attracted scholars both from macro and finance. Interest rate is often assumed as a linear function in the short-term in the canonical finance model (Rudebusch, 2010). Macroeconomic focuses on interest rates in the long-run and is based on economic stabilization goals. The macroeconomic goals use short-term interest rates to set long-terms interest rates depending on the central bank expectation of economic goals. Theoretically, macro-economy and asset prices are inextricably linked. These linkages are associated with real interest rates since asset prices determine asset acquisition (Cecchetti et al., 2000).

In order to understand the drivers of the real interest rate and there effect in the economy, literature focuses on a combination of macro variables and structures, and yield curve in the finance models. These provides a bidirectional interpretation real interest rate and economic growth in the short and long-run periods. Beginning with the Rudebusch-Wu macro-finance model, short-term interest rate provides the flexing point of finance and macro-economic specifications. If the short term interest rate, ς_t, is defined as (Rudebusch, 2010),

$$\varsigma_t = \varpi_0 + \mathfrak{L}_t + \mathfrak{S}_t \tag{2.13}$$

where ϖ_0 is a constant, $\mathfrak{L}_t$ is the level of perceived inflation targets, and $\mathfrak{S}_t$ is the slope factor of cyclical monetary policy response to the economy. Interest rate ς_t in Equation (2.13) can also be presented in the Taylor (1993) rule for monetary policy as,

$$\varsigma_t = \mathfrak{r}^* + \ell_t^* + \mathfrak{g}_\ell(\ell_t - \ell_t^*) + \mathfrak{g}_\mathfrak{y}\mathfrak{y}_t, \tag{2.14}$$

where $\mathfrak{r}^*$ is the equilibrium real interest rate, ℓ_t^* is the targeted inflation rate of the central bank, ℓ_t is the yearly inflation rate and $\mathfrak{y}_t$ is the amount of output gap. The rule set in Equation (2.14)reflect the action of the interest rate controlling body in attempts to met its output goal and stabilize inflation. Equations (2.13) and (2.14) are modeled to form monetary policy reaction function. Interpretation of parameters in Equations (2.13) and (2.14) are linearly linked, for instance, $\mathfrak{L}_t$ is associated with medium term inflation target for the interest rate governing body as perceived by private investors, $\varpi_0 + \mathfrak{L}_t$ is assumed equal to $\mathfrak{r}^* + \ell_t^*$. Investors often have the tendency to modify rate of inflation, thereby changing ℓ_t. Therefore, $\mathfrak{L}_t$ can be modified based on the news about inflation as (Rudebusch, 2010),

$$\mathfrak{L}_t = \sigma_\mathfrak{L}\mathfrak{L}_{t-1} + (1 - \sigma_\mathfrak{L})\ell_t + \vartheta_{\mathfrak{L},t} \tag{2.15}$$

$\mathfrak{S}_t$ in Equation (2.13) is synonymous to $\mathfrak{g}_\ell(\ell_t - \ell_t^*) + \mathfrak{g}_\mathfrak{y}\mathfrak{y}_t$ and help stabilize the real economy and compact inflation to its medium-term target. $\mathfrak{S}_t$ can therefor be modeled as a cyclical response to evaluate deviation of inflation from its target $\ell_t - \mathfrak{L}_t$ and difference from its output potential $\mathfrak{y}$ such that;

$$\mathfrak{S}_t = \sigma_{\mathfrak{S}} \mathfrak{S}_{t-1} + (1 - \sigma_{\mathfrak{S}}) \left[\mathfrak{g}_{\mathfrak{y}} + \mathfrak{g}_{\ell} (\ell_t - \mathfrak{L}_t) \right] + \mathfrak{u}_{\mathfrak{S},t} \tag{2.16}$$

$$\mathfrak{u}_{\mathfrak{S},t} = \sigma_{\mathfrak{u}} \mathfrak{u}_{\mathfrak{S},t-1} + \vartheta_{\mathfrak{S},t} \tag{2.17}$$

Equations (2.16) and (2.17) permit inclusion of policy inertia and serially correlated elements no presented in Equation (2.14). Equations (2.16) and (2.17) are combined with Equation (2.14) based on New Keynesian models as follows;

$$\ell_t = U_{\ell} \mathfrak{L}_t + (1 - U_{\ell}) \left[\mathfrak{a}_{\ell_1} \ell_{t-1} + \mathfrak{a}_{\ell_2} \ell_{t-2} \right] + \mathfrak{a}_{\mathfrak{y}} \mathfrak{y}_{t-1} + \vartheta_{\ell,t} \tag{2.18}$$

$$\mathfrak{y}_t = U_{\mathfrak{y}} \mathfrak{E}_t \mathfrak{y}_{t+1} + (1 - U_{\mathfrak{y}}) \left[\beta_{\mathfrak{y}1} \mathfrak{y}_{t-1} + \beta_{\mathfrak{y}_{t-2}} \right] - \beta_r \left(\varsigma_{t-1} - \mathfrak{L}_{t-1} \right) + \vartheta_{\mathfrak{y},t} \tag{2.19}$$

Equations (2.18) and (2.19) show that inflation rate is dependent on public expectation of the inflation goals $\mathfrak{L}_t$, lags and output gap of inflation. Output $\mathfrak{y}_t$, on the other hand, is a function of expected output, lags of output and real interest rate, ς_t. U_{ℓ} is a measure of the relative importance of forward-backward-looking pricing behavior. $U_{\mathfrak{y}}$ measures the relative significance of expected against lagged output. The lagged output helps account for the real-world cost of adjustment and habit formation.

Chapter 3

Methodology

3.1 Research Type and Objective

The study aimed at modeling the interest rate on economic growth of Kenya between 1965 and 2018. The research specifically focuses on; modeling the interest rate capping and economic growth of Kenya; modeling mathematical relationship between lending interest rate and economic growth of Kenya; estimating mathematical relationship between deposit interest rate and economic growth of Kenya; and approximating mathematical relationship between real interest rate and economic growth of Kenya.

3.2 The Models

The research relies on the previous model described in Chapter 2.

3.2.1 Interest Rate Capping and Economic Growth

A model describing a mathematical relationship between interest rate capping and economic growth of Kenya has been outlined in the Section 2.2. Based on classical economic theory, saving directly related to interest rate, but investment is a function of interest rate, that is,

$$\gamma = f\Bigg(- \tau + \alpha\xi \Bigg), \tag{3.1}$$

where γ is an investment, τ is the interest rate, ξ is income, and α is a constant coefficient of income. Equation (3.1) shows that the interest rate increases the cost of borrowing, thus reducing investment. Chapter 2.2 indicate that economic growth is a factor of investment. Thus, if interest ceiling or capping increases investments, so does it promote economic growth. Therefore, the relationship between economic growth and interest rate can be formulated as Equation (3.1) as,

$$\begin{aligned} E_g \propto \gamma &= f\Bigg(- \tau + \alpha\xi \Bigg), \\ E_g = k_{ec}\gamma &= k_{ec}\Bigg(f\Bigg(- \tau + \alpha\xi \Bigg)\Bigg) \end{aligned} \tag{3.2}$$

where E_g is economic growth and K_{ec} is equality constant.

3.2.2 Lending Interest Rate and Economic Growth

Lending rate caps increases access to credit and stimulate economic growth.Therefore, models of lending interest rates on economic growth are based on limited credit access on investment and productivity. The existing models are based on financial friction and their effects. Thus, if $\bar{l}_{Kenya}$ is the average interest rate cap for all loans in Kenya as defined in Equation (2.2), which can be aggregated as,

$$\bar{l}_{Kenya} = (1+s)\left[l + m\frac{f(p)}{b}\right] \tag{3.3}$$

where s is riskiness of loans, p is productivity index of Kenyan economy, $m = \frac{1}{D+1}$ or market power, b is Fin friction and D is number of lenders (banks) in Kenya. Lending rate is also directly related to investment, thus, by extension to economic growth. Equation (3.4) can thus be written as,

$$E_g = K_{ec}\left((1+s)\left[\bar{l}_{Kenya} + m\frac{f(p)}{b}\right]\right) \tag{3.4}$$

where E_g is economic growth and K_{ec} is equality constant.

3.2.3 Deposit and Economic Growth

A rise in the deposit interest rate is a sign of the direction of interest rate and this depends on first-order effect of the direction of the economy. Every shilling drawn into time deposits require a rise of χ_d, a disposable fund of $1-\chi_d$ cents and a rise for a demand net free by $\eta_d(1-\chi_d)$ cents where η_d can be in both directions (±) and is the fraction of disposable funds assigned to net free reserves. The relationship between interest rate and economic growth can be formulated by Equation (3.5a)

$$\text{maximize } \chi_d - t\chi_T + \eta\,(1-\chi_d) - \eta_T\,(1-\chi_T)\,t \tag{3.5a}$$

subject to

$$\left[\chi_T + \eta_T(\hat{\tau})(1-\chi_T)\right]T(\hat{\tau}) + \left[\chi_D + \eta_D(\hat{\tau})(1-\chi_D)\right]D(\hat{\tau}) = \Gamma \tag{3.5b}$$

$$\mu_T(\hat{\tau})(1-\chi_T)T(\hat{\tau}) + \mu_D(\hat{\tau})(1-\chi_D)D(\hat{\tau}) + \Omega(\hat{\tau}) = G - \Gamma \tag{3.5c}$$

$$T(\hat{\tau}) + D(\hat{\tau}) + \Omega(\hat{\tau}) + \Phi(\hat{\tau}) + \Lambda(\hat{\tau}) = G + \Pi \tag{3.5d}$$

where $0.32 \leq t \ll 0.37$, χ_T is the discount rate, τ_B is bills, τ_L is loans, τ_K is capital, χ_D is time deposit, $T(\hat{\tau})$ is public demand for demand deposits $D(\hat{\chi})$ is time deposits, G is government debt, Γ is the non-borrowed reserve, then $G - \Gamma$ is the interest-bearing bills.

3.2.4 Real Interest Rate and Economic Growth

The real interest rate is an interest rate modified based on the inflation, thus, the lower the real interest rate, the lower the investing cost. Mathematically, low interest rate stimulates the economy, while lower real interest rate spurs spending and higher spending lowers investment, thus hindering economic growth, that is,

$$\begin{aligned} i_{lower} &= K_i E_g \\ i_{r_{lower}} &= K_r s_{spending} \\ s_{spending} &= K_s \frac{1}{E_g} \end{aligned} \tag{3.6}$$

where i_{lower} is lower interest rate, E_g economic growth, $i_{r_{lower}}$ lower real interest rate, $s_{spending}$ spending and K_i, K_r, K_s are equality constants. Thus, we can formulate relationship between real interest rate and economic growth based on

Equation (3.6) as,

$$i_{lower} = K_K \left(\frac{1}{i_{r_{lower}}} \right) \tag{3.7a}$$

subject to Equations (2.13)-(2.19) and modified based on available data for Kenyan Ecomony.

3.3 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 model interest rate on economic growth of Kenya between 1970 and 2018. Regression analysis is done to establish the linear relationship between the dependent variable and independent variables to support the findings from aggregated model from Equations (3.2)-(3.7a).

Chapter 4

Data Analysis

4.1 Introduction

The study modeled interest rate capping and economic growth; mathematical relationship between lending interest rate and economic growth; estimate mathematical relationship between deposit interest rate and economic growth; and approximate mathematical relationship between real interest rate and economic growth in Kenya between 1970 and 2018. Thus, data are collected (presented in Table 4.1) for independent variables (interest rate capping, lending interest rate, deposit interest rate, real interest rate) and dependent variables (economic growth).

Table 4.1: Interest rate variables and economic growth rate for Kenya from 1970 to 2018.

Year	CR %	LI %	DI %	RI %	EG %
1970	2.1885		3.5000		-4.6554
1971	3.7802	9.0000	3.5000	20.0694	22.1739
1972	5.8316	9.0000	3.5000	7.7019	17.0824
1973	9.2812	9.0000	3.5000	-1.0924	5.8966
1974	17.8099	9.5000	4.3150	-5.6435	4.0656
1975	19.1202	10.0000	5.1300	-1.6409	0.8822
1976	11.4490	10.0000	5.1300	-7.4901	2.1540
1977	14.8210	10.0000	5.1300	-5.9023	9.4538
1978	16.9318	10.0000	5.1300	6.7122	6.9125
1979	7.9794	10.0000	5.1300	4.1286	7.6152
1980	13.8582	10.5833	5.7533	0.9426	5.5920
1981	11.6031	12.4167	8.8467	1.4105	3.7735
1982	20.6667	14.5000	12.1975	2.6054	1.5065
1983	11.3978	15.8333	13.2700	3.5724	1.3091
1984	10.2841	14.4167	11.7708	3.8351	1.7552
1985	13.0066	14.0000	11.2500	5.2575	4.3006
1986	2.5343	14.0000	11.2500	4.8645	7.1776
1987	8.6377	14.0000	10.3125	8.1574	5.9371
1988	12.2650	15.0000	10.3333	8.0262	6.2032
1989	13.7893	17.2500	12.0000	6.8152	4.6903
1990	17.7818	18.7500	13.6667	7.3328	4.1921
1991	20.0845	18.9975	14.5000	5.7455	1.4383
1992	27.3324	21.0675		1.8253	-0.7995
1993	45.9789	29.9892		3.4135	0.3532
1994	28.8144	36.2400	15.7200	16.4281	2.6328
1995	1.5543	28.7958	13.5975	15.8016	4.4062
1996	8.8641	33.7867	17.5908	-5.7766	4.1468
1997	11.3618	30.2450	16.7217	16.8796	0.4749
1998	6.7224	29.4900	18.4008	21.0963	3.2902
1999	5.7420	22.3800	9.5508	17.4540	2.3054
2000	9.9800	22.3392	8.1008	15.3274	0.5997
2001	5.7386	19.6658	6.6392	17.8125	3.7799
2002	1.9613	18.4533	5.4867	17.3581	0.5469
2003	9.8157	16.5733	4.1333	9.7705	2.9325
2004	11.6240	12.5317	2.4333	5.0453	5.1043
2005	10.3128	12.8825	5.0825	7.6100	5.9067
2006	14.4537	13.6355	5.1387	-8.0099	6.4725
2007	9.7589	13.3403	5.1623	4.8191	6.8507
2008	26.2398	14.0169	5.3021	-0.9850	0.2323
2009	9.2341	14.8045	5.9670	2.8371	3.3069
2010	3.9614	14.3715	4.5574	12.0282	8.4057
2011	14.0225	15.0468	5.6286	3.8385	6.1083
2012	9.3778	19.7234	11.5721	9.4566	4.5632
2013	5.7175	17.3135	8.6418	11.5478	5.8787
2014	6.8782	16.5139	8.3734	7.8151	5.3571
2015	6.5822	16.0866	9.1889	5.5093	5.7185
2016	6.2972	16.5596	8.6886	10.4298	5.8789
2017	8.0057	13.6676	7.6741	2.7826	4.8625
2018	4.6898	13.0608	8.2927	9.9387	6.3198

Item	KEY
CR	Capping Rate
LI	Lending Interest Rate
DI	Deposit Interest Rate
RI	Real Interest Rate
EG	Economic Growth

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 interest rate capping has never had a trend, thus rising and falling for the entire period under study. However, the interest rate cap in 2018 is

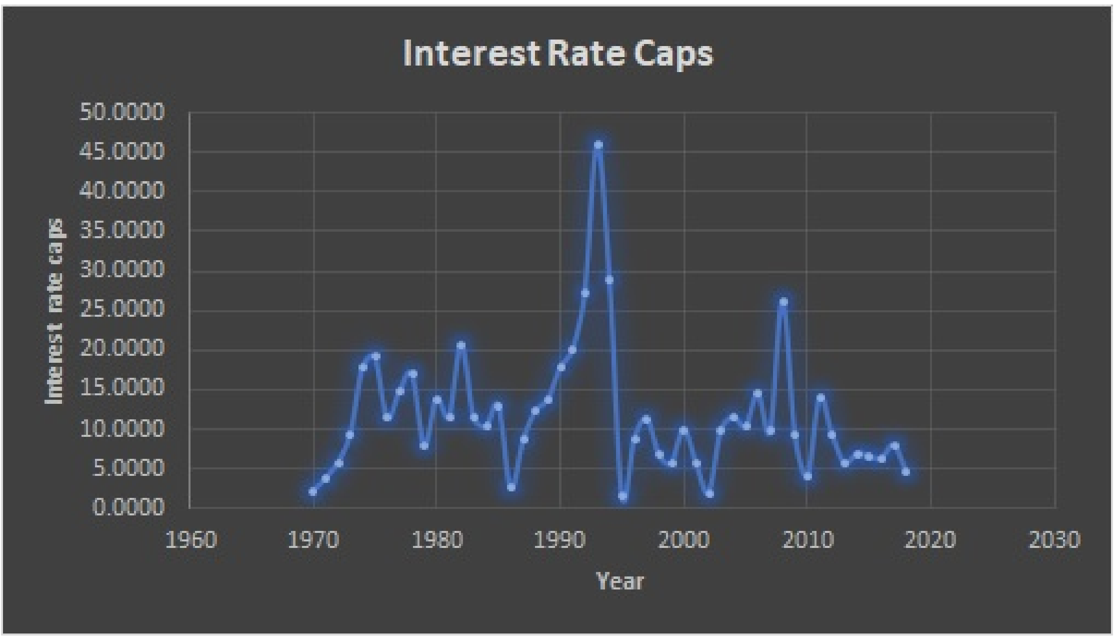

Figure 4.1: Summary of capping rate (analogous to inflation rate) trend from 1970 to 2018.

greater than that of 1970. The highest ever recorded value is in the year 1995.

Figure 4.2 shows a continued rise of lending interest rate from 1970 to 1995. Lending interest rate is also noted to have a continuous fall from 1995 to 2018. However, the lending interest rate in 2018 is greater than that of 1970.

Figure 4.3 indicates a sharp rise in deposit interest rate from 1970 to 1998. This is accompanied by sharp fall to 2004, then rise to 2013. However, the deposit interest rate in 2018 is greater than that of 1970.

Figure 4.4 indicates a zigzag trend of real interest rate between 1970 and 2018. However, unlike other variables, real interest rate in 1970 is greater than that of 2018.

Figure 4.5 shows a sharp increase in economic growth between 1970 and 1971 followed by an almost equal fall. Thereafter, it followed a zigzag trend. However,

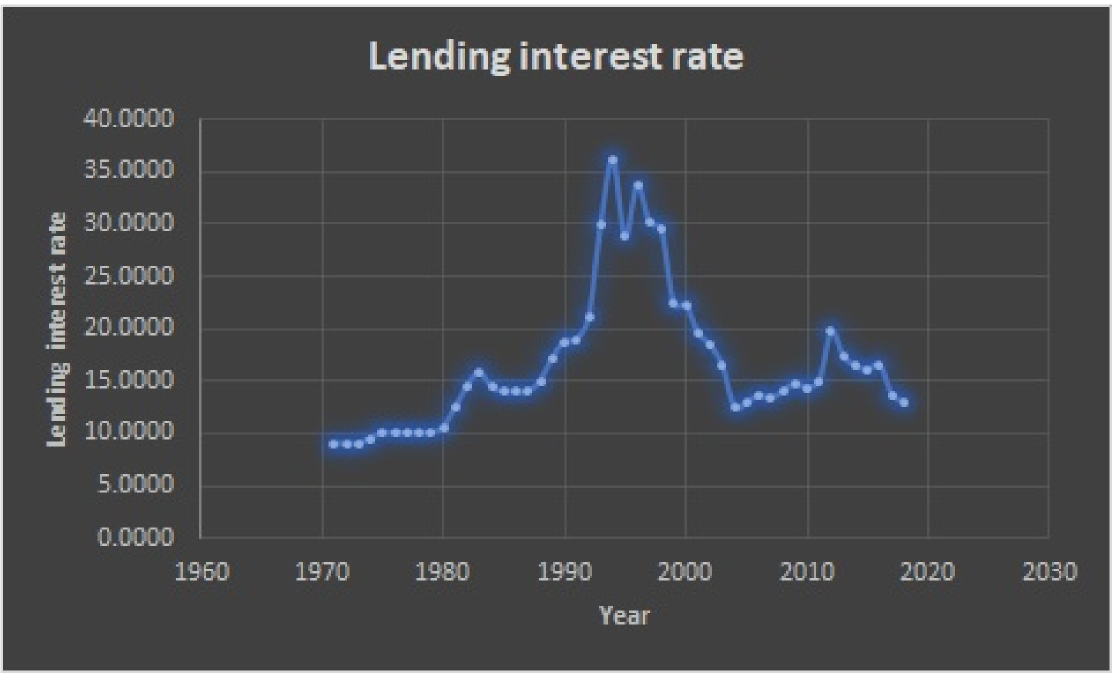

Figure 4.2: Summary of population growth rate trend from 1970 to 2018.

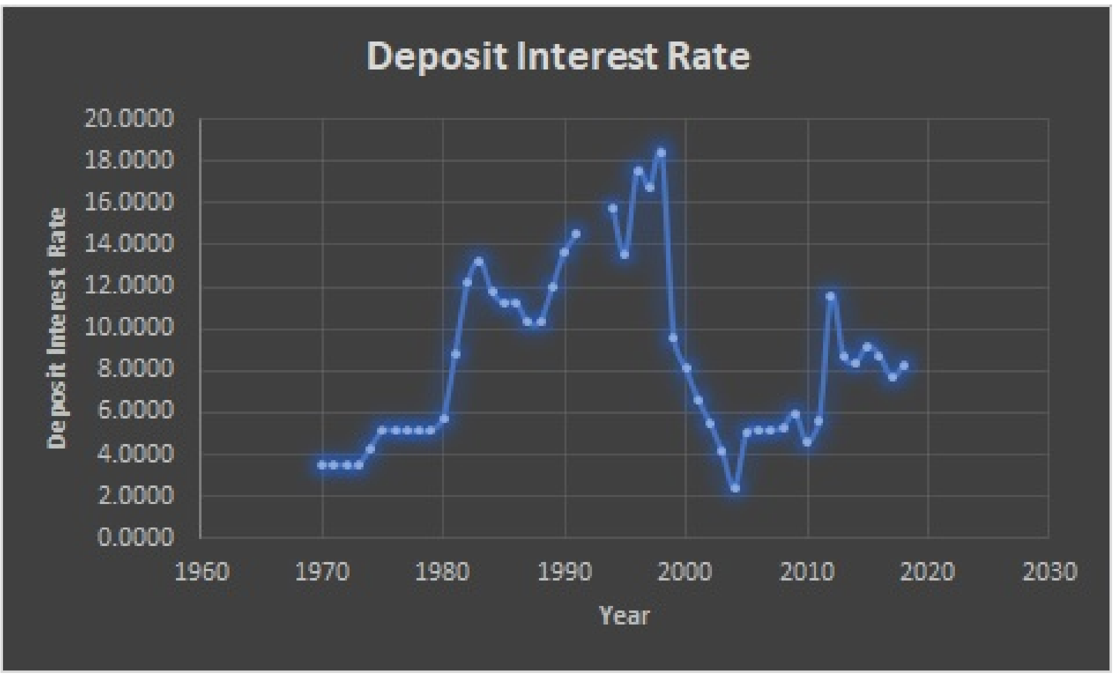

Figure 4.3: Summary of life expectancy trend from 1970 to 2018.

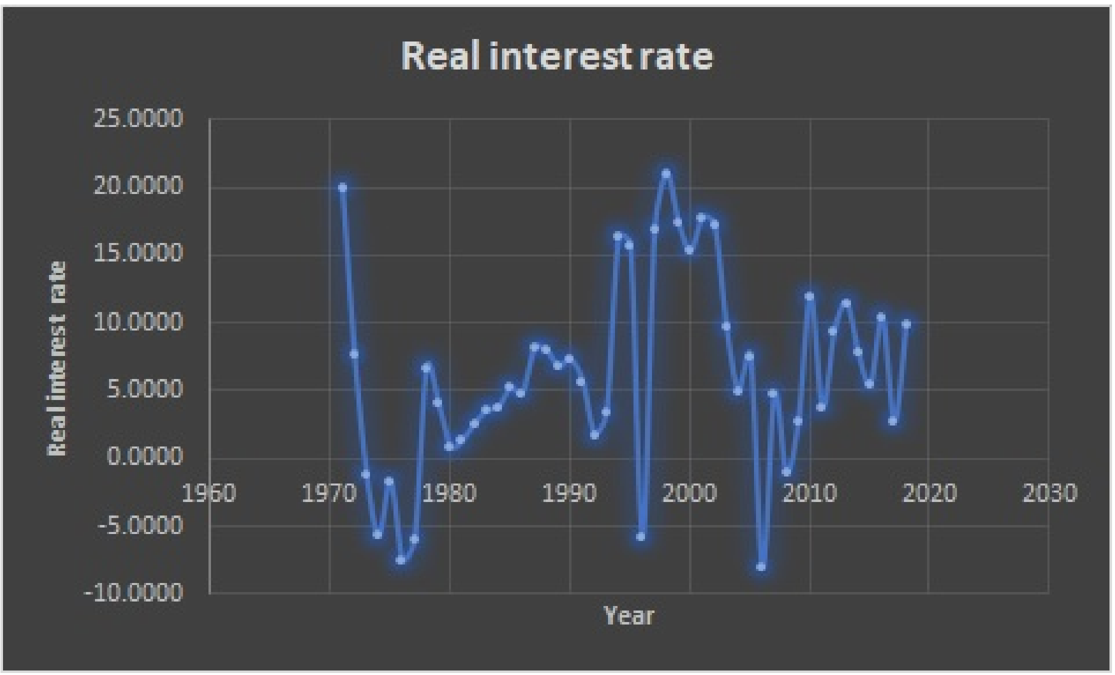

Figure 4.4: Summary of dependency ratio trend from 1970 to 2018.

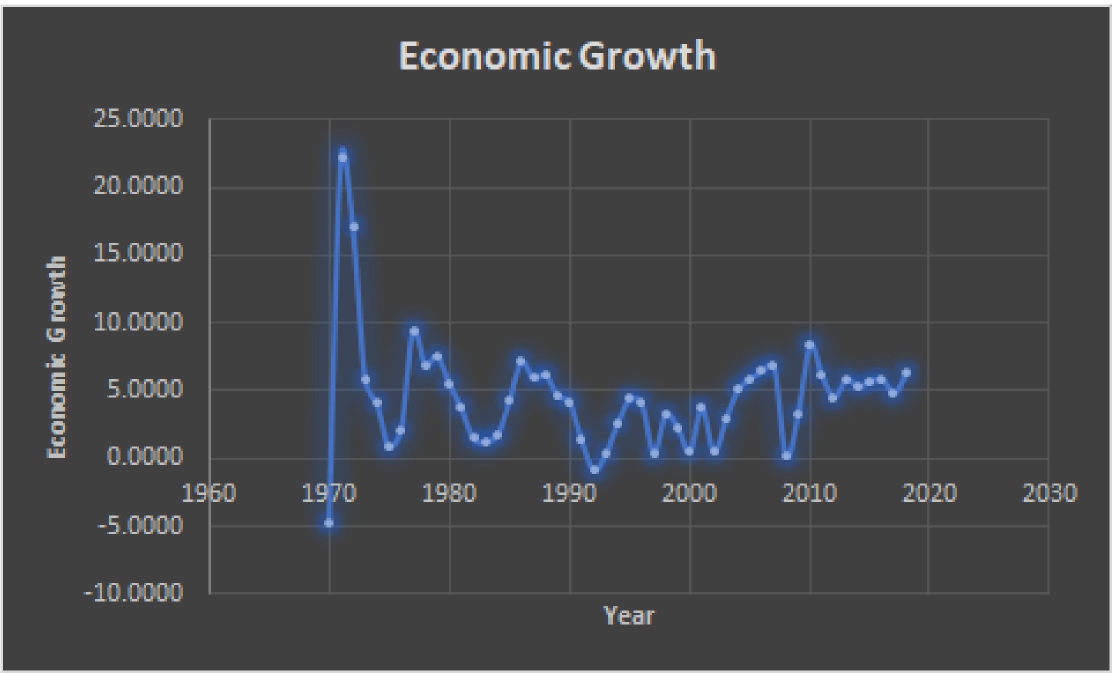

Figure 4.5: Summary of capital investment trend from 1970 to 2018.

the economic growth value of 2018 is greater than that of 1970.

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 the mean capping rate between 1970 and 2018 is 11.7576%, lending interest rate is 16.6423%, deposit interest rate is 8.4417%, real interest rate is 6.4055% and economic growth is 4.5937%. Standard error mean measures accuracy of the data mean. Thus, low standard error mean indicate high accuracy in data values and is desirable statistically. Table 4.2 indicate that only capping interest rate and real interest rate data has standard error mean more than unity, suggesting that all the are less accurate. Economic growth has the lowest standard error mean, suggesting the data entries are more accurate.

Table 4.2: Descriptive statistics of interest rate variables and economic growth for Kenya between 1970 and 2018.

Variable	**Mean**	**Std. Error Mean**
CR	11.7576	1.1536
LI	16.6423	0.9643
DI	8.4417	0.6109
RI	6.4055	1.0430
EG	4.59375	0.5936

Source: Researcher

Correlation Analysis

The study employs Pearson's correlation analysis to find the strength and direction of the linear relationship between dependent (economic growth) and independent variables (interest rate capping, lending interest rate, deposit interest rate, real interest rate). 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 statistical significance relationship between the independent variables (interest rate capping, lending interest rate, deposit interest rate, real interest rate) and dependent variables (economic growth).

Table 4.3: Pearson's correlation values between independent variables (interest rate capping, lending interest rate, deposit interest rate, real interest rate) and dependent variable (economic growth)

Item	Pearson Correlation	Significance
CR	-0.327	0.022**
LI	-0.435	0.002**
DI	-0.301	0.04*
RI	0.12	0.418

*Correlation is significant at the 0.05 level (2-tailed).
**Correlation is significant at the 0.01 level (2-tailed).
Source: Researcher

Table 4.3 indicate that capping interest rate and lending interest rate have negative significant correlation with economic growth. Deposit interest rate also have negative correlation with economic growth but correlation is significant at 0.05 level. Real interest rate have positive correlation with economic growth and the relationship is not significant at any level.

4.1.2 Regression Analysis

Regression analysis presents model summary, ANOVA and regression coefficients.

Model Summary

Model Summary for the modeling mathematical relationship between interest rate and economic growth.

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	.560a	.314	.247	3.394903737	.314	4.684	4	41	.003

a Predictors: (Constant), Real Interest rate, Deposit interest rate, Capping rate, lending interest rate

The model summary results give the strength of the relationship between the dependent variables and the model. R, which is equal to 0.56, is the multiple correlation coefficient and show the linear correlation between the observed and model-predicted values of the economic growth 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 0.314, is the coefficient of determination and shows the variation of the model parameters. Adjusted R Square is a modified R Square statistic based on large parameters in the model. These statistics are important only when there are more than one model to choose.

ANOVA

The resulting ANOVA output is,

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	215.947	4	53.987	4.684	.003b
	Residual	472.540	41	11.525		

	Total	688.487	45			

a Dependent Variable: Economic Growth

b Predictors: (Constant), [Real Interest rate, Deposit interest rate, Capping rate, lending interest rate]

The results above show the F value is 4.684 and using F-distribution table at $\alpha = 0.05$, $F_{0.05;4,41} = 2.605$. Since the F critical is more than F statistics, hence the interest rate variables are significant in finding the mathematical relating to economic growth. The p-value for 4.684 is 0.003 and since $\alpha = 0.05 > 0.003$, implying that the test statistic is significant at that level.

Regression Analysis

The regression analysis showing the coefficients for modeling interest rates indicators as independent variable and economic growth as dependent variable.

Coefficients for regression analysis for interest rates indicators and economic growth

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	10.876	1.651		6.588	.000
	Capping rate	-.159	.096	-.242	-1.654	.106
	lending interest rate	-.255	.139	-.423	-1.831	.074
	Deposit interest rate	-.093	.197	-.099	-.473	.639
	Real Interest rate	.122	.089	.228	1.363	.180

a Dependent Variable: Economic Growth

The regression analysis indicate that regression equation can be formulated as,

$$Eg = 10.876 - 0.159CI - 0.255LI - 0.093DI + 0.122RI. \tag{4.1}$$

Equation (4.1) indicate that only real interest positively influence economic growth. Capping interest rates, lending interest rates, and deposit interest rates have a negative effect on economic growth. Equation (4.1) further suggests that for every unit increase in capping interest rate, economic growth decrease by 0.159 units assuming other variables are constant. Similarly, for every unit increase in lending interest rate, economic growth decrease by 0.255 units when other variables are considered constant. Likewise, for every unit increase in deposit interest rate, economic growth decrease by 0.093 units with other variables assumed constant. A unit increase in real interest rate increases economic growth by 0.122 units considering other variables are kept constant.

4.2 The Model

As described in Chapter 2, the mathematical modeling relationship between interest rate capping and economic growth, lending interest rate and economic growth, deposit interest rate and economic growth and real interest rate and economic growth depends on models described in Sections 4.2.1, 4.2.2, 4.2.3 and 4.2.4 respectively.

4.2.1 Interest Rate Capping and Economic Growth

The relationship between economic growth and interest rate can be formulated as in Equation (3.1) , that is,

$$\begin{aligned} E_g \propto \gamma = f\Bigg(- \tau + \alpha\xi \Bigg), \\ E_g = k_{ec}\gamma = k_{ec}\Bigg(f\Bigg(- \tau + \alpha\xi \Bigg)\Bigg) \end{aligned} \tag{4.2}$$

where γ is an investment, τ is the interest rate, ξ is income, α is a constant coefficient of income and E_g is economic growth and K_{ec} is equality constant.

A summary of regression analysis based on the data presented in Table 4.5 is summarized follows.

Table 4.4: Income per capita GDP (ξ), capping interest rate τ, economic growth (investment) γ for Kenya from 1970 to 2018.

Year	Income (per Capita GDP), ξ	Interest Rate, τ	Economic Growth (Investment), γ
1970	-7.951759602	2.1885	-4.6554
1971	17.88010168	3.7802	22.1739
1972	12.90831855	5.8316	17.0824
1973	2.075056384	9.2812	5.8966
1974	0.27342094	17.8099	4.0656
1975	-2.822627483	19.1202	0.8822
1976	-1.616994398	11.4490	2.1540
1977	5.396619609	14.8210	9.4538
1978	2.929413815	16.9318	6.9125
1979	3.579754521	7.9794	7.6152
1980	1.607989933	13.8582	5.5920
1981	-0.159218312	11.6031	3.7735
1982	-2.342009381	20.6667	1.5065
1983	-2.513365823	11.3978	1.3091
1984	-2.042794477	10.2841	1.7552
1985	0.466465669	13.0066	4.3006
1986	3.30323511	2.5343	7.1776
1987	2.173927184	8.6377	5.9371
1988	2.504359601	12.2650	6.2032
1989	1.12346909	13.7893	4.6903
1990	0.724833716	17.7818	4.1921
1991	-1.85909714	20.0845	1.4383
1992	-3.950175524	27.3324	-0.7995
1993	-2.757426658	45.9789	0.3532
1994	-0.46821651	28.8144	2.6328
1995	1.331428322	1.5543	4.4062
1996	1.155501735	8.8641	4.1468
1997	-2.347172124	11.3618	0.4749
1998	0.439692243	6.7224	3.2902
1999	-0.485156688	5.7420	2.3054
2000	-2.125173164	9.9800	0.5997
2001	0.987024476	5.7386	3.7799
2002	-2.143710276	1.9613	0.5469
2003	0.18086419	9.8157	2.9325
2004	2.28317848	11.6240	5.1043
2005	3.045012048	10.3128	5.9067
2006	3.576204044	14.4537	6.4725
2007	3.933078041	9.7589	6.8507
2008	-2.503373226	26.2398	0.2323
2009	0.50385534	9.2341	3.3069
2010	5.494076785	3.9614	8.4057
2011	3.288144617	14.0225	6.1083
2012	1.8157403	9.3778	4.5632
2013	3.142205435	5.7175	5.8787
2014	2.694788349	6.8782	5.3571
2015	3.116621981	6.5822	5.7185
2016	3.346252153	6.2972	5.8789
2017	2.420020577	8.0057	4.8625
2018	3.896152981	4.6898	6.3198

Regression analysis coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.031	.153		19.833	.000
	interest rate	.015	.010	.028	1.429	.160
	Income	1.040	.021	1.002	50.463	.000

a Dependent Variable: Economic Growth

Regression analysis suggest that Equation (4.2) can be written as,

$$\gamma = 0.15\tau + 1.04\xi$$
$$E_g = k_{ec}\gamma = k_{ec}\Bigg(f\Bigg(-\tau + \alpha\xi\Bigg)\Bigg) \tag{4.3}$$
$$\gamma = -f\tau + f\alpha\xi$$

Equation (4.3) suggest that $-f = 0.15$ and $f\alpha = 1.04$ hence $\alpha = \frac{1.04}{-0.15} = -6.93$. Thus, Equation (4.3) can be written as

$$\gamma = -0.15\left(-\tau - 6.93\xi\right). \tag{4.4}$$

4.2.2 Lending Interest Rate and Economic Growth

If $\bar{l}_{Kenya}$ is the average interest rate cap for all loans in Kenya, s is riskiness of loans, p is productivity index of Kenyan economy, $m = \frac{1}{D+1}$ or market power, b is Fin friction and D is number of lenders (banks) in Kenya. Thus, lending interest rate in Kenya can be estimated by Equation (3.4), that is,

$$E_g = K_{ec}\Bigg((1+s)\Bigg[\bar{l}_{Kenya} + m\frac{f(p)}{b}\Bigg]\Bigg) \tag{4.5}$$

where E_g is economic growth and K_{ec} is equality constant.

A regression analysis of the lending interest rate assuming other parameters are constant yields,

Table 4.5: Values of the parameter for lending interest rate and their sources

Parameter	**Values**	**Source**
D	44	(Cytonn, 2020)
p	2.52	(CEIC, 2020)
s	0.9 (range 0-1)	estimated
b	1.8	(Moll, 2014)

Coefficients of Lending interest rate assuming other variables are kept constant

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	9.086	1.414		6.426	.000
	lending interest rate	-.258	.079	-.435	-3.272	.002

a Dependent Variable: Economic Growth

A regression form of Equation (4.5) is

$$EG = 9.086 - 0.258\bar{l}_{Kenya}, \tag{4.6}$$

whence

$$(1+s)m\frac{f(p)}{b} = 9.086$$
$$\frac{1.9f(p)}{45*1.8} = 9.086$$
$$K_{ec}f(2.52) = 387.351$$

and

$$K_{ec}(1+s) = -0.258 \tag{4.7}$$
$$\rightarrow K_{ec} = \frac{-0.258}{1.9}$$
$$\Rightarrow K_{ec} = -0.1316$$

hence Equation (4.5) becomes

$$E_g = -0.1316\left((1+s)\left[\bar{l}_{Kenya} + m\frac{f(p)}{b}\right]\right)$$

4.2.3 Deposit Interest Rate and Economic Growth

Beginning with Equation (3.5a), we list parameter values and their sources as in Table 4.6. We use the values in Table 4.6 and optimization algorithm to solve optimization problem presented in Equation (4.8). The results obtained through Matlab R2019a suggest that the optimal deposit interest rate as 6.039%.

Table 4.6: Values of the parameter for deposit interest rate and their sources

Parameter	Name	Values	Source
t	Deflationary or inflationary counter-effective measure	0.35 (range $0.32 < t < 0.37$)	(Tobin, 1970)
χ_T	Discount rate	11.6	(CIA, 2020)
τ_B	Bills (Kenyan government spending)	734790.80	(Trading, 2020a)
η_d	Central banks cash reserve rate	10.57	(cbk, 2020)
η	Interbank rate	5.88	(cbk, 2020)
$\Pi = \Lambda$	Capital	-6289.30×10^8	(Trading, 2020b)
χ_D	Time deposit	1026	(Star, 2019)
$D(\hat{\chi})$	Time deposits for public demand	60×10^9	(cbk, 2020)
$T(\hat{\tau})$	Public demand	345.3×10^8	(Nyambura, 2019)
Γ	Non-borrowed reserve	$9,717 \times 10^8$	(Omondi, 2020)
G	Government debt	as at February 2020 $6,158,003.12 \times 10^6$	(cbk, 2020)
Ω	Public demand for bills	1×10^6	(cbk, 2020)
Φ	Number of loans	62	(Star, 2019)

```
%++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
close all;
clear all;
clc;
t=0.35;chi_T=11.6;tau_B=734790.80;Pi =-6289.30; Lambda=-6289.30;chi_D=1026;D=60*10^9;
T=345.3*10^8;Gamma= 9717*10^8;G=6158003.12*10^6;eta_T=10.57;eta=5.88;eta_D=10.88;mu_T=9.79;
Omega=1*10^6;mu_D=6.16;Phi=62;
%chi_d is the deposit interest rate
prob = optimproblem('ObjectiveSense','max');
chi_d = optimvar('chi_d','LowerBound',0);
prob.Objective= chi_d - t*chi_T + eta*(1-chi_d) - eta_T*(1- chi_T ).*t;
cons1 = (chi_T+eta_T*(1-chi_T)).*T + (chi_D + eta_D*(1-chi_D)).*D<=Gamma;
cons2 = mu_T*(1-chi_T)*T+mu_D*(1-chi_D).*D+Omega<=G-Gamma;
cons3 = T + D+Omega+Phi+Lambda<=G+Pi;
%++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
sol.chi_d=0.06039
%*+*+*+*+*+*+*++++++==================================================================
```

$$\text{maximize} \quad \Bigg[\chi_d - t\chi_T + \eta\,(1-\chi_d) - \eta_T\,(1-\chi_T)\,t\Bigg]$$

subject to

$$\Bigg[\chi_T + \eta_T(\hat{\tau})(1-\chi_T)\Bigg]T(\hat{\tau}) + \Bigg[\chi_D + \eta_D(\hat{\tau})(1-\chi_D)\Bigg]D(\hat{\tau}) = \Gamma \tag{4.8}$$

$$\mu_T(\hat{\tau})(1-\chi_T)T(\hat{\tau}) + \mu_D(\hat{\tau})(1-\chi_D)D(\hat{\tau}) + \Omega(\hat{\tau}) = G - \Gamma$$

$$T(\hat{\tau}) + D(\hat{\tau}) + \Omega(\hat{\tau}) + \Phi(\hat{\tau}) + \Lambda(\hat{\tau}) = G + \Pi$$

We combine the results obtained with that of regression analysis presented below when other interest rate variables are assumed constant. This gives a relationship between deposit interest rate and economic growth as

$$Eg = 7.297 - 0.296DI|_{DI \simeq 0.06039}. \tag{4.9}$$

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	7.297	1.314		5.553	.000
	Deposit interest rate	-.296	.140	-.301	-2.118	.040

a Dependent Variable: Economic Growth

4.2.4 Real Interest Rate and Economic Growth

As stated in Section 4.2.4 the lower the real interest rate, the lower the investing cost. We begin from Equation (3.6) to note that lower interest rate is a reciprocal of lower real interest. If i_{lower} is lower interest rate, E_g economic growth, $i_{r_{lower}}$ is lower real interest rate, then the model for approximating mathematical relationship between real interest rate and economic growth can be presented as

$$E_g = \frac{K}{i_{r_{lower}}} \tag{4.10}$$

A regression analysis of economic growth data and reciprocal of real interest rate is summarized below.

Coefficients of regression analysis of economic growth and reciprocal of real interest rate

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	0.004	.606		7.844	.000
	Reciprocal of Real Interest Rate	.359	1.789	.030	.201	.842

a Dependent Variable: Economic Growth

The regression analysis suggests that the model equation for real interest rate in Equation (4.10) can be presented as,

$$Eg = 0.004 + \frac{0.359}{i_{r_{lower}}} \tag{4.11}$$

Equation (4.11) is close to Equation (4.10) since $0.004 \simeq 0$ and $0.359 = K$. Thus, Equation (4.10) becomes,

$$Eg = \frac{0.359}{i_{r_{lower}}}. \tag{4.12}$$

Equation (4.12) is the model equation for approximating a mathematical relationship between real interest rate and economic growth.

Chapter 5

Discussions, Conclusions and Recommendations

5.1 Discussion

The relationship between interest rate indicators and economic growth is subtle in many countries. Technical indicators in developed countries have continued to link interest rates and economic growth, with less work presented in developing countries. In this study, the focus was to model the interest rate on the economic growth of Kenya between 1970 and 2018. The research specifically focuses on 1) model interest rate capping and economic growth, 2) model the mathematical relationship between the lending interest rate and economic growth, 3) estimate relationship between the deposit interest rate and economic growth and 4) approximate mathematical relationship between the interest rate and economic growth in Kenya.

5.1.1 Capping Interest Rate and Economic Growth

Interest rate capping limits the extent of loans and deposit interest rate and fluctuates based on the government directives. Interest rate capping has produced mixed results with economic growth since it may shift the lending preferences. Graphical representation of interest rate capping (assumed analogous to inflation rate for purposes of this study) between 1970 and 2018 shows that it has presented a zigzag trend. The graphs show that the highest increase was between 1985 and 1993. When we compare this trend with a graphical representation of economic growth, we find a similar pattern, that is, zigzag trend. However, a comparison of the trend line between 1985 and 1992 shows a reduction in economic growth. Correlation analysis also indicates a negative relationship between capping of interest rate and economic growth, and the relationship is statistically significant. This observation is similar to that presented in the graphical representation of capping interest rates and economic growth. Tajudeen et al. (2017) also made a similar observation and noted that capping interest rates may shift lending to large corporations hence hindering capital for SMEs, which may stagger economic growth. Mushtaq and Siddiqui (2016) also noted that the high-interest rate prevents economic growth by discouraging investment. This further explains why where the graphical representation show higher capping of interest rate corresponds with lower economic growth and vise versa.

The classical economist also noted that higher interest rates promote savings and hinder economic growth. Thus, we expect the interest rate to have a positive relationship with savings and a negative relationship with economic growth. Regression analysis also indicated that the capping interest rate has a negative effect on economic growth. Thus, the model equation that model interest rate capping and economic growth presented as $\gamma = -0.15\left(-\tau - 6.93\xi\right)$ correlates with all the test done on data. The model equation also gives similar observation, as noted in the existing literature.

5.1.2 Lending Interest Rate and Economic Growth

Lending rates have been used by governments to spur economic growth. Therefore, the existing studies relate lending rates to access to credit, which promotes investment and productivity. Graphical representation of data (see Figure 4.2) shows that lending rates increases between 1970 and 1994, followed by a drop. Graphical representation of data (see Figure 4.5) shows economic growth increase between 1970 and 1971, followed by a drop. The observation is not precise since while lending rate increases the falls continuously, economic growth rate exhibit series of increment followed by decrements for the entire period under study. Correlation analysis shows that the lending rate has a negative relationship with economic growth, and the relationship is statistically significant. Regression analysis also indicates a negative relationship.

These observations are similar to that of Buera and Shin (2013); Itskhoki and Moll (2019); Joaquim and Sandri (2019) who noted that increasing lending rate reduces capital for investment thus hindering economic growth. The model that shows a mathematical relationship between the lending interest rate and economic growth presented in Equation (4.7), that is, $E_g = -0.1316\left((1+s)\left[\bar{l}_{Kenya} + m\frac{f(p)}{b}\right]\right)$, tend to have a similar correlation with findings in correlation and regression analysis.

5.1.3 Deposit Interest Rate and Economic Growth

One of the main specific objectives of the study was to estimate the relationship between the deposit interest rate and economic growth. The graphical representation of data collected between 1970 and 2018 shows that while the deposit interest rate increases between 1970 and 1999 before it falls, economic growth presents a zigzag trend throughout the entire period. Correlation analysis shows the deposit interest rate has a negative relationship with economic growth, and the relationship is statistically significant. Regression analysis also shows a similar observation; that is, the deposit interest rate has a negative relationship with economic growth. These observations are similar to those made by Ganatra (2016), who noted that increasing the deposit interest rate promotes saving and hinders investment in the short term.

A mathematical estimate of the relationship between the deposit interest rate and economic growth is presented as an optimization problem that depends on several parameters, listed in Table 4.6. The solution to the objective function based on estimated parameter values presented in Table 4.6 suggests that the optimal deposit interest rate as of 2019 is 6.039%. An estimated relationship show deposit interest rate negatively affect and economic growth. The observation is in line with those of existing studies.

5.1.4 Real Interest Rate and Economic Growth

Real interest rate fosters financial liberation, promoting savings and investments and growth of the economy in the long-run. A graphical representation of data on the real interest rate in Figure 4.4 show a sharp fall between 1971 and 1976, followed by a rise. The general trend of the real interest rate is similar to that of economic growth (see Figure 4.5). Correlation analysis also indicates an insignificant positive relationship between the real interest rate and economic growth. Regression analysis also indicated that real interest rate have positive effect on economic growth.

The approximate mathematical relationship between the interest rate and economic growth in Kenya presented as $\left(Eg = \frac{0.359}{i_{r_{lower}}} |_{i_{r_{lower}}=RI} \right)$, also indicate positive non-linear relationship between real interest rate and economic growth.

5.2 Conclusion and Recommendation

The relationship between interest rate indicators and economic growth has been studied in this paper. The research has developed and presented 1) a model showing a relationship between interest rate capping and economic growth (see Equation (4.4)), 2) a model showing the mathematical relationship between the lending interest rate and economic growth (see Equation (4.7)), 3) estimated a relationship between the deposit interest rate and economic growth (see Equation (4.8)), and approximated mathematical relationship between the interest rate and economic growth in Kenya (see Equation (4.12)). The model equations developed plus correlation, and regression analysis has indicated that capping interest rate, lending interest rate and deposit interest rate have a negative relationship with economic growth. Real interest rates, on the other hand, have a positive relationship with economic growth. Future studies should present a comparison of short and long term effects of interest rates indicators and economic growth.

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