# Nexus between Saving and Inflation: Evidence from Pakistan


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# Certificate

The thesis entitled "**Nexus between Saving and Inflation: Evidence from Pakiatan"** submitted by **Syeda Zoraiz Fatima** is partial fulfillment for the degree of Master of Science in Economics has been completed under my guidance and supervision. It is certified that she has incorporated the necessary changes suggested by the Examiners during the Viva Voice exam held on May 2, 2024. Now this is ready for further process.

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# DEDICATION

I dedicate this thesis to my beloved mother, who inspired me to enroll in this course of study. The dedication also goes to my family and supervisor, whose support enabled me to successfully complete this research study.

# AUTHOR'S DECLARATION

I, Syeda Zoraiz Fatima, hereby declare that this thesis is entirely my own work. This thesis has never been submitted for any prior degrees. Furthermore, there is no material in this study that has been previously published or written by someone else. It has not been plagiarized from any published source, in whole or in part.

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SYEDA ZORAIZ FATIMA

## TABLE OF CONTENTS

# LIST OF TABLES

# LIST OF FIGURES

# LIST OF ABBREVIATIONS

| | |
|---|---|
| ADF | Augmented Dickey Fuller |
| ADR | Age Dependency Ratio |
| ARDL | Autoregressive Distributed Lag |
| ARMA | Autoregressive Moving Averages |
| ECM | Error Correction Model |
| FDI | Foreign Direct Investment |
| GDP | Gross Domestic Product |
| GFI | Financial Sector Development |
| GGDS | Growth Rate of Gross Domestic Product |
| GY | Growth Rate of Income |
| INF | Inflation |
| OLS | Ordinary Least Squares |
| WDI | World Development Indicators |
| WLS | Weighted Least Squares |

# Abstract

In light of the fact that the saving rate in Pakistan fell sharply from 17.4 percentage of GDP in 2004 to 4.5 percentage of GDP in 2021, this study investigates the extent to which inflation influences this fluctuation in saving rates. The majority of previous studies on saving revolve around estimating the linear impact of inflation on saving but this evidence is inconclusive (Rehan et al., 2019). This inconclusive results may be due to the omission of considerations for non-linear relationships between inflation and saving within the saving equation (Dash and Kumar, 2018). The present study investigates for the first time in the context of Pakistan whether inflation has a non-linear impact on saving that is whether there is a non-linear relationship between inflation and saving. In other words, whether the direction of the inflation-saving relationship differs before and after a threshold level? This study applies regression kink model of Hansen (2017) with an unknown threshold to evaluate the nonlinear effect of inflation on saving spanning 1961Q2 to 2021Q1. The results of the Hansen technique confirm the existence of a non-linear relationship. The results show a U-shaped non-linear relationship between inflation and the growth rate of gross domestic saving. The study finds that there is a change in the direction of the inflation-saving relationship prior to and after the threshold of 6.3% inflation rate.



**Keywords** Growth rate of gross domestic saving, CPI Inflation, Growth rate of Income

# CHAPTER 1

# INTRODUCTION

This chapter provides an overview of the topic of research and its significance. It comprises an overview of the significance of study, research gap, objective of study and research question.

Saving as a percentage of GDP in Pakistan fell sharply from 17.4 percent in 2004 to 4.5 percent in 2021. In light of the recent decline in the saving rate, this study tries to explore whether inflation[1] is one of the factors behind falling saving. The evidence on the effects of inflation on savings is mixed. Several studies, including Ogbokor and Samahiya (2014), Abou El-Seoud (2014), and Taye (2017), have found a positive impact of inflation on saving, leading to macroeconomic uncertainty. This positive impact is often attributed to the precautionary motive for saving. Conversely, other studies, such as those by Sajid and Hafeez (2021), Aleemi et al. (2015), and Ahmad and Mahmood (2013), have found that inflation reduces the incentive to save, with individuals responding rationally.

However, some studies, including Ugah (2022), Tedla (2016), and Aric (2010), have found no significant impact of inflation on saving. These inconclusive results might be attributed to the omission of considerations for non-linear relationships between inflation and saving within the saving equation (Dash and Kumar, 2018). In the absence of addressing this aspect, this study explores the potential non-linear impact of inflation on saving, meaning that the direction of the inflation-saving relationship differs before and after the threshold level.

[1] Inflation refers to the upward movement or increase in the overall price level within an economy. It is characterized by a decrease in the value of money accompanied by rising prices.

Taye (2017) argued that the most significant barriers to generating stronger and more sustained economic development are a lack of national saving. Saving and investment serve as vital components of any country's economic development. In accordance with saving and investment theories, saving comes before investment, resulting in higher economic growth (Odi and Oji, 2020). Based on neoclassical growth theory, Mundell (1963) and Tobin (1965) correctly described the influence of inflation on economic growth and saving. They think that higher nominal interest rates produced by inflation will encourage individuals to save and invest rather than consume. As a result, capital accumulation will increase, stimulating saving and economic expansion. Low national saving represents one of the most significant obstacles to achieving higher and more sustainable economic growth. An increase in the saving rate is instrumental in promoting economic growth. Saving plays a crucial role in economic growth, as accumulated savings serve as the primary source for the capital stock, leading to increased investment, output, and higher employment levels (Solow, 1956).

Aghion et al. (2006) theoretically and empirically demonstrated that increasing saving rates can accelerate economic growth in low-income countries. Hence, understanding saving behavior is crucial for policymakers aiming to design effective policies that promote saving and foster economic growth.

The significance of this study comes from its investigation into the non-linear relationship between inflation and saving behavior, which could reveal either a U-shaped or an inverted U-shaped pattern. These opposing dynamics have significant policy implications, providing valuable insights for forecasting and recommendations. Policymakers can use these insights to develop effective strategies that encourage saving and overall economic stability, focusing on their approach to the eventual shape of the relationship. Furthermore, when the direction of the relationship becomes clear, central banks can use these outcomes to make informed decisions about inflation targets and monetary policy management. This study provides policymakers with valuable insights that can help shape policy decisions and contribute to a better understanding of the complex interplay between inflation and saving behavior.

## 1.1. Historical Background of the Study

Pakistan[2] has experienced several periods of growth: one from 1951/52 to 1958/59, another from 1960/61 to 1969/70, and a final one from 2003/04 to 2008/09. In contrast, there were two stagnation periods: the first from 1970/71 to 1991/92, and the second from 1992/93 to 2002/03.

In the first episode of growth between 1951/52 and 1958/59 the state had a limited surplus because saving and tax collection were expanding slowly, forcing the government to depend on capital inflows from foreign sources. The primary means of funding investments during this phase was the remarkably high profits generated by private businesses. These profits were largely attributed to the economic disruptions caused by the Partition in 1947, and they were further supported by government policies related to trade and currency exchange rates. The government's direct contribution to investment during this time was minimal.

The Pakistani government aimed to increase its surplus during the second growth episode, which lasted from 1960/61 to 1969/70. However, these efforts were only partially successful because saving and tax revenue increased only modestly, moving from low to slightly higher levels. Similarly, to the 1950s, foreign capital inflows accounted for the majority of surplus growth.

The state was somewhat effective in mobilizing a surplus after 2003/04 in the third episode of growth. Saving were increased, current expenditures and imports were decreased, domestic and external debt was managed, public and private company profitability was

[2] McCartney's (2011)

increased, and public investment was increased. As time passed, their efforts waned dramatically.

In the first episode of Stagnation the state's surplus was stagnant because the total saving were constant. This situation applied to both public and private sector saving, with the first being attributed to stagnant tax collections and the other to a slowdown in domestic financial sector development. Despite efforts to increase saving and tax collection, reliance on foreign capital inflows was still required to bridge the saving-investment gap.

The government attempted to increase the surplus during the second period of stagnation, which began after 1992/93. However, due to stagnant total saving, achieving a domestic surplus has become increasingly difficult. Despite its best efforts, the government was unable to increase its contribution to the surplus. As a result, the country relied heavily on foreign capital inflows. Notably, there was no clear sign of increased company profitability, foreign direct investment (FDI) remained relatively low, and governmental investment appeared to become less productive throughout this era.

We may conclude from the preceding explanation drawn from McCartney's (2011) study that episodes of growth and stagnation depends on one common factor, the saving rate, as well as other ones.

## 1.2. Research Gap

Numerous studies have found a linear positive relationship between inflation and saving (Mose and Thomi, 2022; Athukorala and Sen, 2004; Cheng and Li, 2008). The precautionary motive for saving accounts for the positive relationship between inflation and saving. Multiple research studies (Pervez and Khan, 2020; Akram and Akram, 2016; and Shaikh and Sheikh, 2013) have revealed a linear negative relationship between inflation and saving in Pakistan because inflation reduces the incentive to save, and individuals respond rationally.

While some studies found an insignificant effect of inflation on saving includes Rehan et al. (2019), Chaudhry et al. (2014) and Khan et al. (2017). However, theoretical and empirical literature suggest the possibility of non-linear relationship between saving and inflation rate. For example, Thirlwall (1974) proposed a nonlinear relationship between inflation and saving. The saving-inflation curve, according to his theory, has an inverted U shape, indicating the nonlinear relationship. He divides the total saving rate into two parts (a) voluntary saving, which have a negative relationship with inflation, and (b) saving that are favorably connected to inflation due to their beneficial influence on income redistribution.

Dash & Kumar (2018) used Quadratic approach and the Sarel[3] technique to estimate nonlinear relationship. The results do not indicate that inflation exerts a non-linear influence on saving. Previous studies on saving mainly focus on the linear impact of inflation on saving, but the evidence is inconclusive (Rehan et al., 2019). This might be due to the omission of non-linear relationships between inflation and saving in the saving equation (Dash and Kumar, 2018). However, no study has investigated the non-linear relationship between inflation and saving in Pakistan. Therefore, this study explores the possibility of the non-linear relationship between inflation and saving that is the direction of the inflation-saving relationship different before and after the threshold level. This study investigates the nonlinear relationship between inflation and saving in Pakistan using Hansen's (2017) regression kink model.

[3] Sarel (1996) developed a method for investigating the nonlinear effects of inflation on economic growth. They used threshold estimation to determine the threshold inflation level at which the relationship changes. Regression analysis was carried out, with separate equations used for inflation levels below and above the threshold, providing distinct effects on economic growth. This method provided insights into how the impact of inflation varies across regimes.

## 1.3. Objective of the Study

To investigate the non-linear relationship between inflation and saving.

To examining whether the direction of the inflation-saving relationship differs before and after a threshold level.

## 1.4. Research Question

Does a non-linear relationship exists between inflation and saving, that is whether the direction of the inflation-saving relationship differs before and after the threshold level? In other words, whether a threshold exists in the relationship between saving and inflation?

## 1.5. Scheme of Study

The subsequent chapters are organized in the following way: Chapter 2 provides a literature review, Chapter 3 contains data and methods, Chapter 4 contains estimation results and discussion on findings and Chapter 5 concludes the discussion.

# CHAPTER 2

# LITRATURE REVIEW

Literature review[4] is divided into two sections: the first covers the linear relationship between saving and inflation, while the second covers the non-linear relationship between saving and inflation.

## 2.1. Evidence on Linear Relationship

When reviewing the literature, it is clear that there has been a significant amount of research done on the linear relationship between inflation and saving.

### 2.1.1 Positive Linear relationship

There have been several studies that show a linear positive relationship between inflation and saving includes Mose and Thomi (2022) used annual time series data from 1975 to 2020 to investigate the impact of inflation on Kenyan saving culture. They used the ordinary least squares (OLS) estimation approach to examine how inflation explains saving. According to the results, saving are positively associated to inflation and economic growth while consumption expenditure inversely related to national savings. Results show that one percent rise in inflation corresponds to a 0.75 percent increase in the saving rate. According to estimates, rising inflation in Kenya will drive additional expansion in national savings.

Khan et al. (2017) investigated the factors that influence national saving in six South Asian countries: Sri Lanka, Nepal, Pakistan, Bangladesh, India, and Bhutan by using panel data for the period 1989 to 2013. Results of the fixed effect model show that inflation has a

[4] There are many other possibilities of organizing the literature such as by types of saving or region wise etc but this study prefers to organize literature on the basis of linear and nonlinear relationships which is also the focus of this thesis.

statistically significant influence on national savings. The effect of inflation on national saving was positive.

Taye (2017) used annual data from 1974 to 2014 to investigate the impact of inflation on saving in a small open economy of Ethiopia, employing autoregressive distributed lag (ARDL) and Error correction model (ECM). The Co-integration test result by utilizing the ARDL bounds testing technique reveals the existence of a long run relationship amongst variables incorporated in the regression model, as well as between inflation and national saving. The long run estimation result demonstrates that inflation has a significant positive influence on national saving in the long run but a negligible effect in the short run.

Ogbokor and Samahiya (2014) investigated the drivers of saving in Namibia by using data from 1991 to 2012 and employing co-integration and error correction techniques. They worked with quarterly macroeconomic data sets. The co-integration test results indicate a long-run relationship between savings and the explanatory factors employed in their investigation. The findings indicate that inflation has a positive influence on savings. Moreover, deposit rates and financial deepening have insignificant influence on savings.

Abou El-Seoud (2014) investigated how inflation influences the national saving rate in the Kingdom of Bahrain using annual data from 1993 to 2013. They used the co-integration test to investigate the long-run relationship among the variables. The findings obtained show that the inflation rate (as a measure of macroeconomic uncertainty) has a significant positive influence on the national saving rate both in the short run and long run. In the short run, the real GDP growth rate has a favorable influence on national saving, and it is significant at the 5% level in the long run. In the short term, nominal interest rates have a positive and significant influence on national saving rates at the 1% level; however, its effect in the long run was insignificant.

Ozcan et al. (2012) developed an empirical model to examine private saving in Turkey. They used annual data from 1975 to 2008 to investigate how macroeconomic and socioeconomic factors influence private saving. Inflation, income level, terms of trade, real interest rates, young dependency ratio, urbanization rate, economic crisis, and political instability had a significant positive impact on savings, while financial depth, income growth, current account deficit, old dependency ratio, and life expectations had a significant negative impact on savings. Furthermore, they discovered that private savings have high inertia, whereas government savings partially crowd them out.

Chaudhry et al. (2010) used annual data from 1972 to 2008 to explore the long-run and short-run predictors of national savings in Pakistan. Using Johansen's co-integration method and the Vector Error Correction Model, it was found that inflation had a long run significant positive influence on national savings in Pakistan.

Cheng and Li (2008) investigated the factors of the Malaysian saving function. They examined the factors affecting national saving in Malaysia using annual data from 1980 to 2006. As independent variables, they utilized per capita income, saving account deposit rate, inflation rate and money supply. The findings supported the hypothesis that income level positively affects national saving. According to the results inflation showed a positive influence on Malaysian national saving.

Athukorala and Sen (2004) investigated the factors influencing the private saving in India using annual data from 1954 to 1998. Their results revealed a positive relationship between the inflation rate and the private saving rate, particularly when associated with macroeconomic uncertainty. This relationship was attributed to the precautionary saving motivation, as people tend to save more during times of economic uncertainty.

Deaton (1977) introduced the involuntary savings hypothesis as an explanation for the positive relationship between inflation and the saving rate. According to this hypothesis, households, lacking timely information about the prices of all goods and services, erroneously perceive an increase in the general price level as a rise in certain relative prices. Consequently, when faced with a general price level increase, consumers, in a state of confusion, cut back on consumption. This results in involuntary savings. Empirical testing of Deaton's model in both the UK and the USA validated this hypothesis.

### 2.1.2 Negative Linear relationship

Numerous studies have shown a linear negative relationship between savings and inflation. The negative relationship between the savings rate and inflation is that as inflation increases it will reduce the incentive to save and individuals respond rationally. Furthermore, when inflation exhibits high variability, the Real Interest Rate (RIR) becomes volatile and unpredictable, discouraging private saving.

Sajid and Hafeez (2021) used data from 1973 to 2020 to investigate the influence of inflation, agricultural production, real interest rate and fiscal deficit on national savings in Pakistan. The autoregressive distributed lag model and the error correction model are employed to investigate co-integration and short-run dynamics, respectively. The study's findings confirm that the inflation rate and fiscal deficit have a negative impact on national savings in both the long and short term. Iqbal et al. (2021) investigated the influence of macroeconomic and demographic factors on the gross domestic savings of Asian countries focusing on the period from 1990 to 2019. The countries under consideration include Pakistan, India, China, Indonesia, and Bangladesh. The study employs the Fully Modified Ordinary Least Square (FMOLS) estimation method to derive long-run coefficients. The findings indicate a significant impact of all variables on gross domestic savings. Notably, macroeconomic factors such as GDP per capita and interest rates exhibit a positive relationship with savings, while inflation had a negative influence on saving. Moreover, demographic factors, including the dependency ratio, negatively influence gross domestic savings in the sampled countries. Conversely, variables such as infant mortality rate and urbanization emerge as positive determinants of savings.

Akram and Akram (2016) used data to examine Pakistan's saving behavior from 1973 to 2013. Inflation, age dependence, and foreign savings have been proven to have negative and significant associations with all three types of savings (national savings, public savings, and private savings), but economic growth and financial sector development increase savings in Pakistan. According to the findings, interest rates have insignificant influence on national savings and private savings. Akram and Akram (2015) examined the savings behavior of four Muslim-majority nations (Pakistan, Bangladesh, Malaysia, and Indonesia) and four non-Muslim-majority countries (India, Sri Lanka, Thailand, and the Philippines) from 1975 to 2012. The Panel method was utilized. It was discovered that the influence of inflation had a significant negative impact on saving in both categories of nations (Muslim and Non-Muslim). The influence of real interest rates on saving is insignificant in Muslim nations, but significant in non-Muslim ones. Furthermore, the result revealed that age dependency and foreign savings have a negative influence on savings in both categories of nations, although per capita GDP and financial sector development had a significant positive impact.

Aleemi et al. (2015) investigated the factors influencing national savings in Pakistan. They used data from 1980 to 2010 to examine the relationship between the saving rate and several selected economic factors such as inflation, real interest rate, real GDP growth rate, and government current spending. In a dynamic regression model based on ARMA specification.

Adelakun (2015) looked into the relationship between saving, investment, and economic development. The study utilized an error correction approach to analyze data spanning 29 years. The findings revealed a positive relationship between Nigerian savings, investment, and economic growth. In the saving equation, the inflation rate contributes adversely to saving.

Shaikh and Sheikh (2013) employed both OLS multiple regression and the Prais-Winsten estimation approach. They investigated the macroeconomic factors influencing saving in Pakistan using annual data from 1974 to 2009. According to their research, the saving rate is inversely connected to inflation. The negative impact of inflation on the saving rate is attributed to the dampening effect on the real return on savings. Individuals with rational expectations of a higher future price level tend to increase present consumption and save less for the future.

Ahmad and Mahmood (2013) examined the factors that influence national savings. They used yearly data from 1974 to 2010 to examine the macroeconomic determinants of savings in Pakistan. They employed the ADRL bound testing technique for co-integration to assess the strength of the long run relationship and the ECM for short run dynamics. They found that the inflation rate had a negative influence on national savings.

Muhammad et al. (2010) emphasize the importance of both saving and investment for driving economic development through capital accumulation. Secondary yearly data from 1974 to 2009 were used to examine the impacts of per capita income, lagged saving, and the inflation rate on national saving. The study applies the least squares method. According to empirical results, per capita income and the lagged saving rate have a favorable impact on national savings in Pakistan. In contrast, the inflation rate has a negative influence on national savings.

Lahiri (1989) investigated the influence of inflation on private saving for eight Asian countries. According to the findings of his research, inflation has a negative effect on private saving on average; however, the impact appears to alter significantly across countries. In Indonesia, both anticipated and unanticipated inflation reduced private savings. Unanticipated inflation reduced private savings, whereas anticipated inflation had no significant effect in India. In Korea and the Philippines, however, only anticipated inflation played a role: it harmed private savings in Korea and appeared to have the opposite effect in the Philippines. In the two low-inflation economies of Malaysia and Singapore, as well as Sri Lanka and Thailand, inflation, whether anticipated or not, has no effect on private consumption-saving behavior. This was attributed to these developing countries' limited development of financial markets, which resulted in lower actual interest rates and decreased saving.

### 2.1.3 Inconclusive Evidence on Linear relationship

Numerous studies, including Chopra (1988) and Fortune (1981), have shown the reasons why the influence of inflation on savings is unclear. According to Chopra (1988), the impact of inflation on savings is determined by how people respond to increases in inflation. If people shift their savings from financial to physical assets and consumer durables, current savings will drop due to spending connected with these consumer durables. Furthermore, as uncertainty increases, the value of having money decreases, resulting in higher spending and lower savings. Wealth owners, on the other hand, who want to keep their wealth's true worth, would increase their savings in an inflationary environment to keep the required amount. In the framework of the life cycle theory of savings, if the economy lacks a precise and well-established institutional structure or network for social security, healthcare, and so on, inflation would promote relatively large savings. As a result, the total impact of general inflation on saving is unclear.

Fortune (1981) presented a theoretical framework that described the ambiguous relationship between saving and inflation. This framework classified consumption into two types: durable goods and non-durable goods. It meant that people could replace their nominal savings with purchases of durable goods. Consequently, when anticipated inflation in the prices of durable goods increased, consumers tended to buy more durable items, reducing their nominal savings. Higher anticipated inflation in nondurables, on the other hand, causes households to reduce consumption, resulting in higher saving rates. As a result, the overall effect of inflation on savings remains unknown. Fortune's theory was supported by empirical evidence.

Numerous studies, including Ugah (2022), Rehan et al. (2019), Khan et al. (2017) and Tedla (2016), Chaudhry et al. (2014) and Aric (2010), have resulted in inconclusive results. In the case of Nigeria, Ugah (2022) applied an Error Correction Model annual data from 1990 to 2019. The results revealed that the inflation rate in Nigeria had no impact on domestic savings.

Rehan et al. (2019) looked at the influence of inflation on savings using quarterly data from 1995Q1 to 2018Q4. They used the ARDL model and found that neither long-term nor short-term inflation had an impact on national saving in Pakistan.

Khan et al. (2017) investigated the factors influencing gross domestic saving rates in Pakistan, China, Singapore, Japan, Turkey, and Russia. They examined annual data spanning 1995 to 2016. The findings of secondary data demonstrated that foreign direct investment and inflation have no impact on gross domestic saving. However, factors such as age dependency ratio, money supply growth (M2), gross domestic product and per capita income exhibit a positive impact on gross domestic saving.

Tedla (2016) conducted an investigation into the determinants of gross domestic saving in East African countries, namely Ethiopia, Kenya, Mozambique, Rwanda, Tanzania, and

Uganda, utilizing annual panel datasets spanning from 1991 to 2012. The study employs the Fixed Effects (FE) model to determine the key factors influencing domestic saving in the region. The results of the estimation indicate that variables such as inflation rate, the working age group as a percentage of the total population, age dependency ratio to working age, money and quasi-money as a percentage of GDP, and government expenditure as a percentage of GDP do not attain statistical significance at conventional levels. However, GDP per capita growth and the degree of urbanization emerge as the sole determinants significantly influencing gross domestic saving in the East African region.

Chaudhry et al. (2014) examined the short- and long-run relationships between national savings and their monetary and fiscal drivers in Pakistan by taking annual data from 1972 to 2010. The monetary determinants are inflation rate, Money Supply (M2) and the deposit rate, whereas the fiscal determinants are the budget deficit, government expenditures, government savings, and government income (taxation) of national savings. The autoregressive distributed-lag and error correction model are used to estimate the long- and short-run elasticity. In both the short and long run, the analysis suggests a positive relationship between the inflation rate and national saving. But the coefficients lack statistical significance. In the short term, the coefficient of government saving is greater than in the long run. Deposit rate and government spending have a favorable long-run and short-run connection with national saving. In the long run, M2 is inversely connected to national saving, although the relationship is quite substantial.

Aric (2010) investigated the factors that influence the savings in Asia-Pacific Economic Cooperation (APEC) member countries, targeting a group of sixteen countries from 2000 to 2013. According to the study, inflation has insignificant impact on savings in APEC nations.

## 2.2. Evidence on Non-Linear Relationship

Numerous studies have investigated a non-linear relationship between savings and inflation. Dash & Kumar (2018) provided evidence for the non-linear relationship between inflation and saving. Dash and Kumar (2018) investigated the non-linear relationship between inflation and savings using annual time series data from 1970 to 2012. They emphasized the importance of considering structural breaks, as neglecting them can introduce significant bias into the projected impact of inflation. They estimated a non-linear relationship using quadratic approach and the Sarel technique. Surprisingly, their findings revealed that the beneficial effect of inflation on saving, as a result of income redistribution, consistently outweighed the voluntary reduction in saving due to higher inflation rates. Surprisingly, the findings did not indicate the non-linear relationship. Consequently, there was no identified threshold inflation.

Iyer (2018) explored the role of inflation in explaining the downturn of savings in India, utilizing data spanning the period 1971-2015. Employing the Autoregressive Distributed Lag Co-integration technique, the study revealed negative influence of inflation on saving in long run. The analysis further disaggregated between the impact of inflation on financial and physical savings. The findings indicated a threshold inflation value of 6.5% that minimizes the residual sum of squares for both financial and physical savings. Below this threshold, inflation exhibited a positive influence on financial savings, while beyond it, the effect reversed. Similarly, with regard to physical savings, inflation below the threshold negatively affected savings, while inflation above the threshold contributed an increase in physical savings. These findings underscore the distinctive nature of Indian savings behavior, wherein physical assets like gold and real estate serve as effective hedges against inflation.

Krishnamurthy and Saibaba (1981) conducted research that supports the non-linear relationship between saving and inflation rates. They investigated the relationship between inflation and saving for India. The study revealed the non-linear relationship between inflation and savings in the Indian context. They examined the relationship for three Periods: 1952/53-1969/70, 1952/53-1975/76, and 1952/53-1978/79. Their findings revealed that the coefficients related to inflation of the household and domestic savings rate equations were around one-third lower over the 1952/53-1975/76 period, which included a period of relatively high inflation from 1970/71 to 1975/76, contrasted to the coefficients obtained for both of the other two periods, namely 1952/53-1969/70 and 1952/53-1978/79. It is interesting to note that the sign of the inflation coefficient stayed positive throughout the three sub-periods. This means that moderate levels of inflation exhibit a beneficial effect on savings rates. However, this is not the case for high inflation rates. The aforementioned finding emphasizes the existence of threshold inflation and, as a result, the existence of a non-linear relationship.

Thirlwall (1974) proposed a nonlinear relationship between inflation and saving. The saving-inflation curve, according to his theory, has an inverted U shape, indicating the nonlinear relationship. He divides the total saving rate into two parts (a) voluntary saving, which have a negative relationship with inflation, and (b) saving that are favorably connected to inflation due to their beneficial influence on income redistribution. As inflation functions as a form of taxation on money holdings, voluntary saving diminish as inflation accelerates. The influence of inflation on income distribution unfolds through two channels: firstly, by shifting income from the personal to the corporate sector when wage increases fail to keep pace with inflation, and secondly, by redistributing real income from the private sector (both personal and corporate) to the government sector. Consequently, the inclination to save is assumed to be lower in the personal sector compared to the corporate sector, and similarly lower in the private sector compared to the government sector. At first, during periods of low inflation, a decline in voluntary saving combined with an increase in saving as a result of income redistribution results in an upward trend in the overall saving rate. This trend will continue until the decrease in voluntary saving outweighs the beneficial effect of income redistribution on saving. Consequently, the overall saving rate starts diminishing beyond a threshold of inflation. As per the theory's premise, saving demonstrates a linear relationship with moderately low inflation rates, but once a threshold point is reached, saving decreases as inflation continues to rise.

The empirical literature presents inconclusive evidence regarding the impact of inflation on savings. Some studies suggest a negative effect, while others indicate a positive influence. Notably, certain research findings highlight the insignificance of inflation on savings, possibly due to the omission of nonlinear relationship within the saving equation. As a result, this study investigates the non-linear impact of inflation on saving in Pakistan.

# CHAPTER 3

# DATA AND METHODOLOGY

This chapter describes the nature of data and methodology used to determine the relationship between Inflation and Gross domestic saving growth rate.

## 3.1. Theoretical Framework

The saving behavior of economic agents is explained by four widely accepted theories. These theories include Absolute Income Hypothesis (AIH) put forth by Keynes in 1936, the Relative Income Hypothesis (RIH) proposed by Duesenberry in 1949, the Permanent Income Hypothesis (PIH) presented by Friedman in 1957, and the Life-Cycle Hypothesis (LCH) by Modigliani and Brumberg (1954).

Keynes Absolute Income Hypothesis establishes a relationship between income and savings, arguing that disposable income has a beneficial impact on both saving and consumption. According to Keynes, savings and consumption rise as absolute or disposable income increases. If all other things stay the same, he predicts that consumption will rise less as income increases. As a result, since consumption does not increase in line with income, an increase in disposable income will probably result in a greater percentage of rise in savings. Furthermore, Keynes' theory implies that wealthy individuals save a larger proportion of their income than people with lower incomes.

According to Duesenberry (1949), a household's ability to consume is dependent on the relative position of household income compared to other households. Thus, for a given relative income distribution, a household's income savings percentage is expected to be unique and positively associated with its percentile position in the income distribution. The

RIH makes the assumption that the percentage of income saved remains unaffected by the absolute level of income. This implies that a person with a higher income distribution position would have a higher Marginal Propensity to Save (MPS). Moreover, according to the RIH, an increase in a household's wages won't necessarily lead to a corresponding rise in consumption, implying that the household will save more money overall.

Milton Friedman put forth the Permanent Income Hypothesis in 1957, which is based on the notion that consumption is a continuous function of income. This theory, known as consumption smoothing, contends that temporary fluctuations in income have little influence on permanent consumption. Patterns of consumption can be impacted by variables that affect permanent income, including human capital, wealth, age, and income distribution. Friedman asserts that individuals primarily consume income perceived as permanent, rather than transitory income. This implies that past behavior largely determines current consumption spending. However, variations in transitory income can influence savings, with higher transitory income correlating with higher saving.

The key factors of the model are based on the life-cycle hypothesis (LCH) as proposed by Modigliani and Brumberg (1954) and later extended by Modigliani and Ando (1957). In accordance to this hypothesis, aggregate savings arise from the accumulation of wealth by individuals throughout their working years over dis-saving during retirement. Central to the LCH is the notion that individuals strategically plan their lifetime savings and consumption decisions to achieve a balance in their consumption levels across different life stages. By adhering to the principles of the LCH, the model recognizes the deliberate long-term financial planning undertaken by individuals, emphasizing the importance of maintaining stable consumption levels over time. As a result, fluctuations in savings can be attributed to variations in factors such as consumer income, wealth, and age.

The Life-Cycle Hypothesis proposes that individuals seek to balance their consumption patterns over their lifetime, saving during periods of higher income and spending during periods of lower income. Compared to other theories like the AIH, RIH, and PIH, the LCH offers a more comprehensive understanding of how people manage their finances throughout their lives.

One of the key advantages of the Life-Cycle Hypothesis is its ability to accurately explain long-term saving behavior. Unlike the Absolute income hypothesis, which focuses solely on current income levels, the LCH considers individuals' expected lifetime income, providing a forward-looking perspective that aligns better with actual saving and consumption patterns.

Moreover, while the Relative Income Hypothesis highlights the influence of social comparison on consumption decisions, the LCH integrates this aspect within a broader framework that accounts for changes in income and consumption throughout an individual's life. Similarly, while the PIH underscores the importance of permanent income in determining consumption, it doesn't fully address how individuals adjust their saving and consumption behaviors as they progress through different stages of life. The LCH, however, explicitly incorporates these lifecycle dynamics, offering a more nuanced understanding of saving behavior.

Aligned with the life cycle hypothesis, saving behavior is primarily influenced by demographic and economic factors. By focusing exclusively on the age dependency ratio, economic growth, and financial sector development, the model remains theoretically coherent and straightforward, facilitating clearer interpretation and explanation of the results. This approach is consistent with the framework utilized by the IMF (1990), which also emphasized these core variables in its analysis.

### 3.1.1. Inflation (INF):

The influence of inflation on savings in the traditional life-cycle model is derived from its role in determining the real returns on savings, which are represented by the real interest rate. This argument is based on the assumptions that saving behavior is free of money illusion, and that inflation has no actual balancing effect. But these assumptions have been subjected to valid criticism. To begin, the uncertainty of future income caused by inflation could lead to increased savings as a precaution. This may be particularly accurate for households in developing economies, where income prospects are not more certain than in developed economies. Second, the influence of inflation on real wealth may have an impact on saving habits. If individuals strive to maintain a desired level of wealth or liquid assets relative to their income, inflation-driven increases in savings may occur (Hussein et al., 2017).

According to Juster and Wachtel (1972), inflation can actually have a positive influence on saving due to a bias in consumer expectations. According to them, people are more likely to anticipate a rise in prices than a rise in their income. As a result, when there is rapid inflation, majority of consumers perceive it as a fall of their expected real income. This unmet expectation of lower real income results in a higher level of saving. Inflation and saving have a positive relationship, according to studies such as Mose and Thomi (2022), Athukorala and Sen (2004), and Cheng and Li (2008).

The inverse relationship between the saving rate and inflation demonstrates that consumers make rational decisions over their lifetime regarding how to allocate resources across different time periods. Increased inflation decreases the motivation to save, resulting in rational adjustments (Shaikh & Sheikh, 2013). Ahmad and Mahmood (2013), Sajid and Hafeez (2021), and Akram and Akram (2016) are studies that found a negative relationship between inflation and saving.

According to Chopra (1988), the direction of the inflation coefficient is determined by the decisions that are made by households when faced with rising inflation. Initially, as households shift their focus from monetary savings to tangible assets, nominal savings tend to drop. As a result, in order to protect the real worth of their wealth, they might cut their consumption and boost their savings. The general effects of inflation are hazy. For the reasons stated above, inflation has an unclear effect on the savings rate. As a consequence of these justifications, this study incorporates inflation into the model.

### 3.1.2. Growth Rate of Income (GY):

According to the basic Life cycle hypothesis, as real per capita income experiences growth, savings tend to increase. This viewpoint emphasizes that the savings rate is closely related to the rate of growth in per capita income, instead of being influenced by the level of per capita income itself (Dash & Kumar (2018). Consequently, this study considers growth rate of income as an explanatory variable (Athukorala & Sen, 2004; Dash & Kumar, 2018). However, GDP growth (annual %) is used as income growth (GY). An increase in the growth rate of GDP is likely to have a beneficial influence on savings. Inclusion of GDP growth encompasses most of the macroeconomic variables since economic growth is highly correlated with these variables as shown by Sala-i-Martini (1997).

### 3.1.3. Age Dependency Ratio (ADR):

Regarding the age distribution of the population, the Life cycle hypothesis makes a clear prediction: if the percentage of the working population increases so will the saving rate and if the proportion of the population that is inactive or reliant is large, the savings ratio will be low. As a result, the age dependency ratio is used as an explanatory variable in this study. Several previous studies have included ADR as a factor, including Agrawal et al. (2010), Modigliani and Ando (1957), Lahiri (1989), Loayza et al. (2000), and Modigliani and

Brumberg (1954). ADR is taken as the proportion of dependents (those under 15 or over 64) to the population of working age (15–64).

### 3.1.4. Financial Sector Development (GFI):

The availability of financial institutions is crucial in encouraging savings. Financial saving has increased as a result of easier access to bank branches and more alternatives for investing and saving. Thus, it is anticipated that financial growth would have a favorable impact on savings. Consequently, financial sector development is considered as an explanatory variable (Odi & Oji, 2020; Athukorala & Sen, 2004; Dash & Kumar, 2018; Ugah, 2022). To gauge the progress of the financial sector, this study employs broad money growth (Dash & Kumar, 2018). Broad money or financial development is highly correlated with other financial variables.

The variables are selected in accordance with the literature already in existence. There exists a strong correlation between inflation and real interest rates, including major proxies of interest rates such as the lending interest rate (%), interest rate spread (lending rate minus deposit rate, %), and deposit interest rate (%). The policy interest rate, which is used by the State Bank of Pakistan as a policy tool to control inflation and stabilize inflation expectations in the economy, is also a proxy for interest rates. To combat rising inflation, the State Bank of Pakistan often raises the policy interest rate. Consequently, including both inflation and interest rates in the model could lead to multicollinearity issues, which might distort the estimation results. By omitting interest rates from the model, we can avoid redundancy and potential problems associated with multicollinearity, thereby enhancing the robustness and interpretability of the model's findings. A correlation matrix is provided in the Appendix.

## 3.2. Data and Variable Description

### 3.2.1. Data

This study incorporates the growth rate of income (GDP growth), age dependency ratio, and financial sector development as control variables, while inflation as the main Independent variable. The dependent variable is the growth rate of gross domestic saving[5], which is manually[6] derived from gross domestic saving. All data are sourced from the World Bank's World Development Indicators (WDI).

Due to the limited availability of data, this study faces a challenge in meeting the requirements of Hansen's technique, which typically demands a large dataset. To address this constraint, the annual data covering the years 1960 to 2021 is converted into quarterly data, spanning from 1961Q2 to 2021Q1. This transformation was implemented in an effort to augment the dataset size and enhance the applicability of Hansen's technique to the available information.

[5]Saving Rate indicates the proportion of income that is being saved at a specific point in time, while the Growth Rate of Saving measures the rate of change in total saving over time, represents the percentage increase or decrease in saving from one period to another.

[6] The formula to calculate the growth rate of GDS involves comparing the saving in one period to the saving in a previous period, expressed as a percentage: Growth Rate of GDS = [(GDS in current period - GDS in previous period) / GDS in previous period] * 100.

### 3.2.2. Variable Description

**Table 3.1 Description of Variables**

| **Variables** | **Measurement/Proxy** | **Abbreviation** |
|---|---|---|
| **Dependent Variable** | | |
| Growth rate of gross domestic saving | Growth rate of gross domestic savings (% of GDP) | GGDS |
| **Main Variable of Interest** | | |
| Inflation | Inflation, consumer prices (%) | INF |
| **Control Variables** | | |
| Growth rate of Income | GDP growth (%) | GY |
| Age Dependency Ratio | Age dependency ratio (% of working-age population) | ADR |
| Financial Sector Development | Broad money growth (% of GDP) | GFI |

**Note:** Data Source of all variables is World Development Indicators (WDI)

### 3.3. Methodology

The initial step involves conducting unit root tests to assess the stationarity of the time series data. Following the unit root tests, the empirical model is formulated to examine the relationship GGDS and key factors like GY, INF, ADR, and GFI. After specifying the empirical model, the study employs threshold methodology, such as the regression kink model, to explore non-linear relationships, particularly between inflation and saving.

### 3.3.1 Unit Root Tests

The majority of modeling techniques used in time series analysis are mainly focused with stationary data. A time series is said to be weakly stationary if its value seems to revert to its long-run average value and the characteristics of the data series are unaffected by time-related changes. Non-stationary time series, on the other hand, do not tend to revert to their long-run average value; consequently, their mean, variance, and co-variance fluctuate with time.

The first step is to investigate the characteristics of series graphically and statistically. Graphs serve as the most informal method for determining the series' stationarity. Statistical tests, however, are necessary for the final judgment. Unit root tests present statistical proof for a particular series' stationarity.

The 'unit root test' is the statistical approach used to determine the stationary of a series. The commonly used stationarity test is the ADF (Augmented Dickey-Fuller) test.

### Augmented Dickey Fuller Test

One of most frequent approach for testing unit root is the Augmented Dickey-Fuller (ADF) test. Assume we have a $y_t$ series for checking a unit root. The ADF model ultimately tests the unit root as below. Lags of $\Delta Y_t$ are included to control for autocorrelation.

$$\boldsymbol{\Delta Y_t = \mu + \delta Y_{t-1} + \sum_{i=1}^{k} \beta_i \; \Delta y_{t-i} + e_t} \qquad \textbf{(3.1)}$$

Where

δ $= \rho - 1$

$\rho$ = Coefficient of $y_{t-1}$ in an auto-regressive equation of $y_t = \rho y_{t-1} + y_t$ which $\rho$ is a coefficient of correlation$(-1 \leq \rho \leq +1)$. For a unit root, $\rho$ = 1 that implies δ = 0.

ADF Hypothesis

Null Hypothesis; δ=0 indicates series has a unit root (the series is non-stationary).

Alternative Hypothesis; δ<0 indicates series has no unit root (the series is stationary).

If the null hypothesis is rejected (i.e., δ is statistically significantly different from zero) it implies that the series is stationary.

### 3.3.2 Empirical Model

The basic empirical model is

**GGDS= f (INF, GY, ADR, GFI, GGDS (-1))**

Where GGDS, GY, INF, ADR, and GFI are the growth rate of gross domestic saving, GDP growth, inflation, age dependency ratio, and financial development growth rate, respectively. GGDS serves as a dependent variable. The independent variables are the GY, INF, ADR and GFI. GY represents the growth effect, ADR represents the life-cycle effect and GFI represents financial sector expansion (Dash & Kumar, 2018). A lag of GGDS is included as an explanatory variable to avoid spurious regression even in stationary case (Ghouse et al., 2024)

### 3.3.3 Threshold Methodology

In order to achieve the objective of the study, that is to test the non-linearity, this study follow Hansen (2017)[7], Arby & Ali (2017)[8] and Yemba et al., (2020)[9].

## Regression Kink Model

A regression kink model (also known as a continuous threshold model) is a threshold regression that is restricted to being continuous except at the threshold level. This study applies Hansen (2017) regression kink model[10]. Hansen's technique estimates the parameters in the regression kink model, including an unknown threshold, and it also provides the asymptotic distribution of these parameters, as well as bootstrap confidence intervals for the regression function. The model's functional form is as follows:

$$\boldsymbol{GGDS_t = \beta_1(INF_t - \gamma)_- + \beta_2(INF_t - \gamma)_+ + \beta_3' z_t + e_t} \quad \textbf{(3.2)}$$

In this model $\boldsymbol{\gamma}$ is threshold level of inflation and $\boldsymbol{z_t}$ represents vector of all relevant control variables including the intercept. $\boldsymbol{e_t}$ Represents the error term. Notably, the model incorporates the lag of the dependent variable as part of the vector. This lag term is specifically introduced to address residual serial correlations.

The model's parameters are $\boldsymbol{\beta_1 \beta_2, \beta_3'}$ and $\boldsymbol{\gamma}$. In accordance with Hansen (2017), this study uses the notation $(a)_-$ = min [a, 0] to denote the negative segment of a real number 'a,' similarly, $(a)_+$ = max [0, a] serves to represent the positive segment. These notations are used to represent various aspects of a real number 'a' within the range of possibilities for the threshold inflation rate, which allows the determination of a threshold inflation rate that can be negative. It should be noted that the inflation rate has been divided into two parts: one below the threshold level $\boldsymbol{(INF_t - \gamma)_-}$ and one over it $\boldsymbol{(INF_t - \gamma)_+}$. In accordance with

[7] Investigates "Regression Kink With an Unknown Threshold"
[8] Examines "Threshold Level of Inflation in Pakistan"
[9] Investigates "Non-linear effects of inflation on economic growth in the Democratic Republic of the Congo"
[10] This study used Hansen's (2017) R-code with some modifications to employ Hansen's kink model.

Hansen (2017), the preceding period's inflation rate is used as the threshold variable in this study. This choice is intended to protect against potential endogeneity issues. $\boldsymbol{\beta_1}$ represents the change in the growth rate of gross domestic saving resulting from a rise in the inflation rate below the threshold, whereas $\boldsymbol{\beta_2}$ represents the change in growth rate of gross domestic saving caused by a rise in the inflation rate above the threshold. Equation (3.2) depicts a regression kink model with a continuous regression function for variables INF and z. However, at the threshold value INF = γ, there is a discontinuity (kink) in the slope with respect to INF. Because the threshold is unknown, this study must calculate it endogenously in this model. Model (3.2) is a Non-linear model; the parameters are estimated using least squares criterion.

Let

$$\boldsymbol{INF_t}(\boldsymbol{\gamma}) = \begin{pmatrix} (\boldsymbol{INF_t} - \boldsymbol{\gamma})_- \\ (\boldsymbol{INF_t} - \boldsymbol{\gamma})_+ \\ \boldsymbol{z_t} \end{pmatrix} \quad \textbf{(3.3)}$$

The matrix form of equation (3.2) is as follows:

$$\boldsymbol{GGDS_t = \beta' INF_t(\gamma) + e_t} \quad \textbf{(3.4)}$$

Where, β = $\beta_{1,}\beta_2, \beta_3'$

The least squares criterion is

$$\boldsymbol{S_n(\beta, \gamma)} = \frac{\mathbf{1}}{\mathbf{n}}\sum_{\boldsymbol{t=1}}^{\boldsymbol{n}}(\boldsymbol{GGDS_t} - \boldsymbol{\beta' INF_t}(\boldsymbol{\gamma}))^2 \quad \textbf{(3.5)}$$

The joint minimize of $\boldsymbol{S_n}$ is the least square estimators $\boldsymbol{\hat{\beta}}, \boldsymbol{\hat{\gamma}}$

$$(\boldsymbol{\hat{\beta}}, \boldsymbol{\hat{\gamma}}) = \underset{\boldsymbol{\beta \epsilon \mathbb{R}^{k-1}, \gamma \epsilon \Gamma}}{\boldsymbol{argmin}} \boldsymbol{S_n(\beta, \gamma)} \quad \textbf{(3.6)}$$

The least square criterion function $\boldsymbol{S_n(\beta, \gamma)}$ has a quadratic form with respect to β but is non-convex with respect to $\gamma$. A strategy that combines concentration and grid search is advantageous for improving computational efficiency. It can be expressed clearly with concentration.

$$\hat{\boldsymbol{\gamma}} = \underset{\boldsymbol{\gamma \epsilon \Gamma}}{\mathbf{argmin}} \min_{\boldsymbol{\beta \epsilon \mathbb{R}^{k-1}}} \boldsymbol{S_n(\beta, \gamma)}$$

$$\hat{\boldsymbol{\gamma}} = \underset{\boldsymbol{\gamma \epsilon \Gamma}}{\mathbf{argmin}} \, \mathbf{S_n^*}(\boldsymbol{\beta}, \boldsymbol{\gamma}) \quad \textbf{(3.7)}$$

Γ represents the inflation threshold space.

$$\mathbf{S_n^*}(\boldsymbol{\gamma}) = \boldsymbol{S_n}\left(\hat{\beta}(\boldsymbol{\gamma}), \boldsymbol{\gamma}\right) = \frac{\mathbf{1}}{\mathbf{n}} \sum_{\boldsymbol{t=1}}^{\boldsymbol{n}} (\boldsymbol{GGDS_t} - \hat{\boldsymbol{\beta}}(\boldsymbol{\gamma})' \boldsymbol{INF_t}(\boldsymbol{\gamma}))^{\mathbf{2}} \quad \textbf{(3.8)}$$

The coefficient $\hat{\beta}(\boldsymbol{\gamma})$ represents the result of the least square regression of $GGDS_t$ on the variables $INF_t(\boldsymbol{\gamma})$ for fixed $\boldsymbol{\gamma}$. Equation (3.8) represents the concentrated sum of squared error function.

There are several steps to solving equation 3.7. The initial step is to perform a grid search over $\boldsymbol{\gamma}$. Following the identification of γ, the coefficient estimates $\hat{\beta}$ are calculated using the standard least squares method, with $GGDS_t$ regressed on $INF_t(\hat{\boldsymbol{\gamma}})$. The fitted regression function is written as follows:

$$\boldsymbol{GGDS_t} = \hat{\boldsymbol{\beta}}' \boldsymbol{INF_t}(\hat{\boldsymbol{\gamma}}) + \hat{\boldsymbol{e}}_{\boldsymbol{t}} \quad \textbf{(3.9)}$$

The term $\hat{\boldsymbol{e}}_{\boldsymbol{t}}$ in equation (3.9) denotes the residuals derived from nonlinear least-squares estimation.

Error variance $\sigma^2 = Ee_t^2$ is estimated through

$$\hat{\boldsymbol{\sigma}}^{\mathbf{2}} = \frac{\mathbf{1}}{\mathbf{n}} \sum_{\boldsymbol{t=1}}^{\boldsymbol{n}} \hat{\boldsymbol{e}}^{\mathbf{2}} = \mathbf{S_n^*}(\hat{\boldsymbol{\gamma}}) \quad \textbf{(3.10)}$$

The very first step in estimation is deciding upon the range of values considered for the threshold parameter, which is defined as Γ = [1, 20]. This ensures that a minimum of 5% of the dataset falls below the lower threshold and at least 10% falls above the upper threshold. The minimization of equation (3.7) is then determined by computing $\mathbf{S}_{\mathbf{n}}^{*}(\boldsymbol{\gamma})$ on a discrete grid with 0.1 increments. The least-square coefficients are then estimated at each grid point for $\boldsymbol{\gamma}$, and the least-square criterion $\mathbf{S}_{\mathbf{n}}^{*}(\boldsymbol{\gamma})$ is computed. Then, plot a graph with the least-square criterion on the y-axis and the threshold parameter ($\boldsymbol{\gamma}$) on the x-axis, and find the $\boldsymbol{\gamma}$ value where the least square criterion is at its minimum.

## Testing for Threshold Effect

It is unclear whether or not the threshold model is significant relative to the linear regression model, given each of the models rely on the same number of regressors. According to Hansen (2017), to assess the significance of the regression kink model as compared to the linear model, an F-test is essential. The null hypothesis is as follows

$$\boldsymbol{H_o}: \ \boldsymbol{\beta_1} = \boldsymbol{\beta_2} \quad \text{(This implies that there is no kink)}$$

The linear model is:

$$\boldsymbol{GGDS_t} = \boldsymbol{\beta_1 INF_t} + \ \boldsymbol{\beta'_3 z_t} + \boldsymbol{e_t} \tag{4.2}$$

Since linear model (4.2) stays under the restriction that $\boldsymbol{\beta_1} = \boldsymbol{\beta_2}$, it is nested in the threshold model (3.2). Model (4.2) does not include the threshold parameter. If F-statistic is greater than the critical value of F, it implies rejecting the null hypothesis in support of the existence of the threshold effect.

Least square is a suitable linear model estimator. As a result, these estimates are

$$\boldsymbol{GGDS_t} = \boldsymbol{\tilde{\beta}_1 INF_t} + \ \boldsymbol{\tilde{\beta}'_3 z_t} + \boldsymbol{\tilde{e}_t} \tag{4.3}$$

The error variance estimate is

$$\tilde{\boldsymbol{\sigma}}^{2} = \frac{\mathbf{1}}{\mathbf{n}}\sum_{t=1}^{n} \tilde{e}_t^2$$

F-statistics is as follows

$$T_n = \frac{n(\tilde{\sigma}^2 - \hat{\sigma}^2)}{\hat{\sigma}^2}$$

Where $\hat{\boldsymbol{\sigma}}^{2}$ the previous threshold regression model error variance, and the new regression linear model error variance is $\tilde{\boldsymbol{\sigma}}^{2}$.

According to Hansen (2017), the following algorithm is utilized to test a regression kink model.

1. Generate n iid (independent and identically distributed) draws $u_t$ from the N (0, 1) distribution.
2. Set $y^*_{t=} \tilde{\epsilon}_t u_t$ where $\tilde{\epsilon}_t$ are the OLS residuals from fitted linear regression (4.3)
3. Estimate the linear model (4.3) and the regression kink model (3.9) by utilizing the observations $(GGDS^*_t, z_t, , INF_t)$, and obtain the error variance estimates $\boldsymbol{\sigma}^{\sim *2}$ and $\hat{\boldsymbol{\sigma}}^{*2}$ and the F-statistic

$$T^*_n = \frac{n(\sigma^{\sim *2} - \hat{\sigma}^{*2})}{\hat{\sigma}^{*2}}$$

4. Perform this B times in order to get a sample of simulated F statistics $T^*_n(1), \ldots, T^*_n(B)$
5. Calculate the p-value as the percentage of simulated F statistics that are greater than the actual value: $P_n = \frac{1}{\mathbf{B}}\sum_{b=1}^{B} \mathbf{1}\ (T^*_n(b) \geq T_n)$
6. Calculate the level α critical value $c_\alpha$ as the empirical 1-α quantile of the simulated F statistics if desired. $T^*_n(1), \ldots, T^*_n(B)$

7. If $p_n < \alpha$, or equivalently if $T_n > c_\alpha$ , reject $H_0$ in preference towards $H_1$ at the significance level α.

The number of bootstrap replications, set to B=10,000 because according to Hansen (2017), the number of bootstrap replications, must be sufficiently large to make sure that the p-value $p_n$ is accurate.

## Inference on the Regression Coefficients

In order to determine the certainty of estimated threshold, this study makes use of the algorithm suggested by Hansen (2017) to establish confidence intervals through wild bootstrap confidence intervals for parameters. A criterion-based test through Wild bootstrap is used to test for the threshold parameter.

$H_o: \boldsymbol{\gamma} = \boldsymbol{\gamma}_0$

$H_1: \boldsymbol{\gamma} \neq \boldsymbol{\gamma}_0$.

The null hypothesis $H_o: \boldsymbol{\gamma} = \boldsymbol{\gamma}_0$ asserts that the threshold parameter $\boldsymbol{\gamma}$ is equals to a specific threshold value $\boldsymbol{\gamma}_0$, whereas the alternative hypothesis $H_1: \boldsymbol{\gamma} \neq \boldsymbol{\gamma}_0$ implies that the threshold parameter $\boldsymbol{\gamma}$ is not equal to $\boldsymbol{\gamma}_0$, indicating a presence of threshold effect in the model.

$\sigma^{\wedge 2}(\boldsymbol{\gamma}) = S_n^*$ is an estimator of error variance when $\boldsymbol{\gamma}$ is fixed. If the F-type statistic $F_n(\boldsymbol{\gamma}_0)\ where,\ F_n(\boldsymbol{\gamma}) = \frac{n(\hat{\sigma}^2(\gamma) - \hat{\sigma}^2)}{\hat{\sigma}^2}$ exceeds the bootstrap critical value[11], the null hypothesis is rejected.

$$F_n(\boldsymbol{\gamma}) = \frac{n(\hat{\sigma}^2(\gamma) - \hat{\sigma}^2)}{\hat{\sigma}^2} \quad \textbf{(4.5)}$$

[11] $C_\gamma = \{\gamma : F_n(\gamma) \leq c_{1-\alpha}\}$

According to Hansen (2017), the null hypothesis is rejected when the bootstrap critical value of the F-test exceeds the asymptotic critical value of the F-test.

According to Hansen (2017), the following algorithm is utilized for Wild Bootstrap Confidence Intervals for Parameters.

1. Generate n iid (independent and identically distributed) draws $u_t$ from the N (0, 1) distribution.
2. Set $e_{t=}^{*}\ \hat{e_t} u_t$ where $\hat{e_t}$ the OLS residuals from fitted regression kink model (3.9) are.
3. Set $GGDS_t^* = \hat{\beta}'\, INF_t(\hat{\gamma}) + e_t^*$ , where $(z_t, INF_t)$ are the sample observations, and $(\hat{\beta},\ \hat{\gamma})$ are the least-square estimates.
4. Using the observations $(GGDS_t^*, z_t, , INF_t)$, estimate the regression kink model (3.9), parameter estimates $(\hat{\beta}^*,\ \hat{\gamma}^*)$, and $\sigma^{\wedge *2} = \frac{1}{n}\sum_{t=1}^{n} e_t^{\wedge *2}$ ,where $e_t^{\wedge *} = GGDS_t^* - \hat{\beta}^{*\prime} INF_t(\gamma^{\wedge *})$.
5. **5.** Calculate the F- statistics for γ

$$F_n^* = \frac{n(\sigma^{\wedge *2}(\hat{\gamma}) - \hat{\sigma}^{*2})}{\hat{\sigma}^{*2}}$$

Where $\sigma^{\wedge *2}(\hat{\gamma}) = \frac{1}{n}\sum_{t=1}^{n} e_t^{\wedge *}(\hat{\gamma})^{2}$ and $e_t^{\wedge *}(\hat{\gamma}) = GGDS_t^* - \hat{\beta}^*(\gamma^{\wedge})' INF_t(\gamma^{\wedge})$.

6. Perform this B times in order to get a sample of simulated coefficient estimates $(\hat{\beta}^*, \hat{\gamma}^*)$ and F statistics $F_n^*$.
7. Create 1-α bootstrap confidence intervals for the coefficients $\beta_1, \beta_2, \beta_3$ by the symmetric percentile method: the coefficient estimates plus and minus the (1-α) quantile of the absolute centered bootstrap estimates.
8. Calculate the 1-α quantile $c_{1-\alpha}^*$ of the simulated F statistics $F_n^*$

9. Create 1-α bootstrap confidence intervals for γ as the set of γ for which the empirical F statistics $F_n\,(\gamma)(4.5)$ are smaller than the bootstrap critical value $c^*_{1-\alpha}$.

$$C^*_\gamma = \{\,\gamma\,:\;F_n(\gamma)\;\le\;c^*_{1-\alpha}\}.$$

The upcoming chapter focuses on analyzing the relationship between inflation and gross domestic saving growth using a regression kink model. It begins by ensuring the stationarity of all variables through unit root tests and proceeds with graphical analysis to visually represent trends in savings and inflation. The chapter then details the estimation of the kink regression model, revealing nuanced insights into the relationship between these economic variables.

# CHAPTER 4

# RESULTS AND DISCUSSIONS

This section describes the study's findings, which began by looking at the stationary aspects of all the variables. Because Hansen's technique required that all series be strictly stationary, the unit root test is crucial to determining the order of integration of the variables and preventing spurious regressions.

## 4.1. Unit root tests

The most commonly used stationary test is the Augmented Dickey Fuller unit root test. So, this study used ADF. To begin, look at the stationarity of both dependent and independent variables at (i) constant only and (ii) constant and time trend. The results of the unit root tests are shown in Table 4.1.

**Table 4.1 (2) Unit Root Test Results**

| | **ADF Test** | |
|---|---|---|
| | **Intercept** | **Trend and Intercept** |
| **Variables** | At Level | At Level |
| **GGDS** | -5.69*** | -5.89*** |
| **INF** | -4.04*** | -4.03*** |
| **GY** | -3.28** | -4.73*** |
| **ADR** | -2.81* | -3.26* |
| **GFI** | -3.92*** | -3.9*** |

**Notes:** **1.** *, ** and *** signify significance at the 10%, 5% and 1% levels, respectively.

**2.** The test equation contains both the trend and the intercept at the level.

According to the ADF test findings show that the dependent variable and all the independent variables are stationary at the level means integrated of order zero I (0). Hansen's technique is employed in this study because the variables are stationary at level, which meets the Hansen's technique requirement.

## 4.2. Graphical Analysis

The relationship between savings and inflation has received considerable attention in the literature. A high inflationary situation impacts the actions of almost all economic players, including investors, savers, consumers, and producers. Furthermore, consistently high inflation devalues the local currency in terms of foreign exchange rates. Such uncertainties, in turn, have a negative impact on economic activity. Low and stable inflation, on the other hand, enables economic agents to predict the end result of their own economic decisions with a reasonable degree of certainty. A graphical analysis (Figure 4.2.1, Figure 4.2.2) of the savings and inflation trends reveals that there have been a few periods when high inflation has negatively affected savings. Furthermore, there have been many periods when high inflation and high savings coexisted, as well as low inflation and high savings.

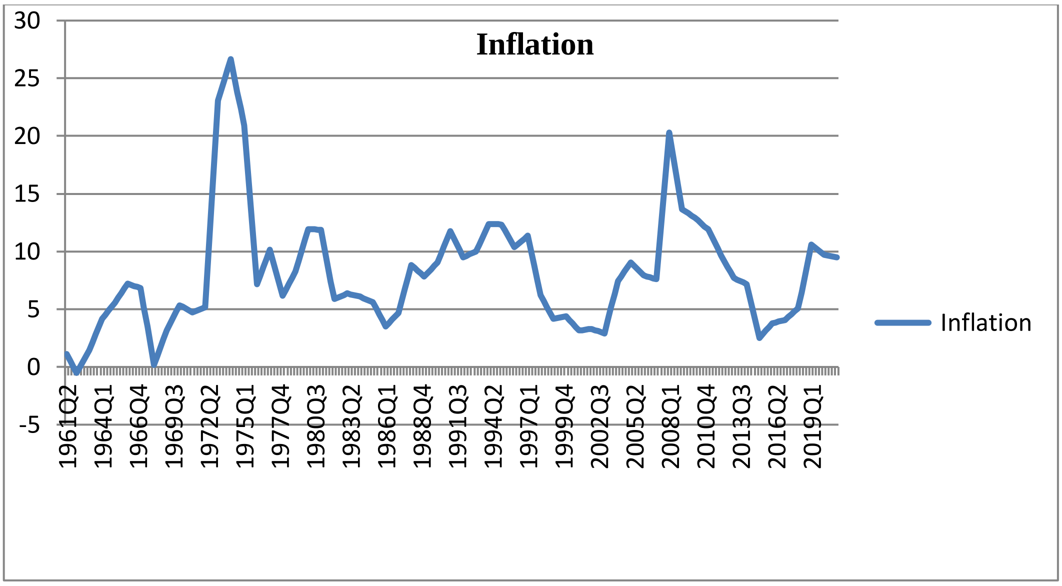


**Figure 4.2.1 Inflation**[12]

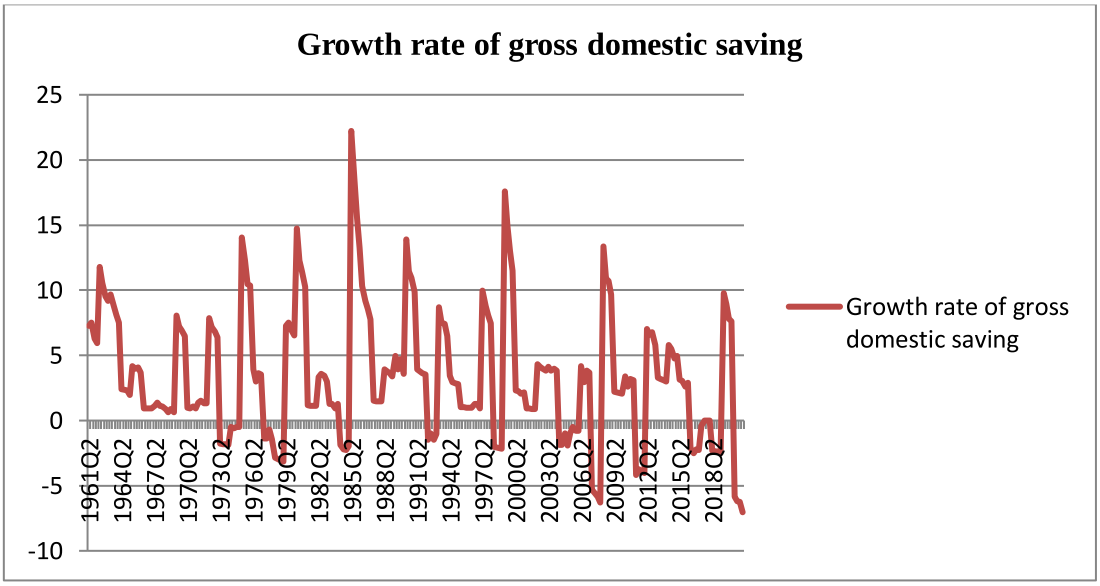


**Figure 4.2.2 Growth rate of Gross Domestic Savings**[13]

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[12] Source [The yearly inflation and gross domestic saving data sourced from the World Development Indicators (WDI) and transformed into quarterly intervals using EViews]

The scatter plot analysis (Figure 4.2.3) presents a U-shaped relationship between inflation and the growth rate of gross domestic saving. In Figure 4.2.3, the red point indicates the kink point (threshold), with the fitted regression line corresponding to equation (3.2) and pointwise 90% confidence intervals. Figure 4.2.3 shows low inflation has a negative slope, while inflation above the 6.3 percent threshold has a positive slope.

Figure 4.2.3 shows that the confidence intervals remain quietly constant around the optimal threshold of 6.3 percent and slightly widen beyond this threshold.

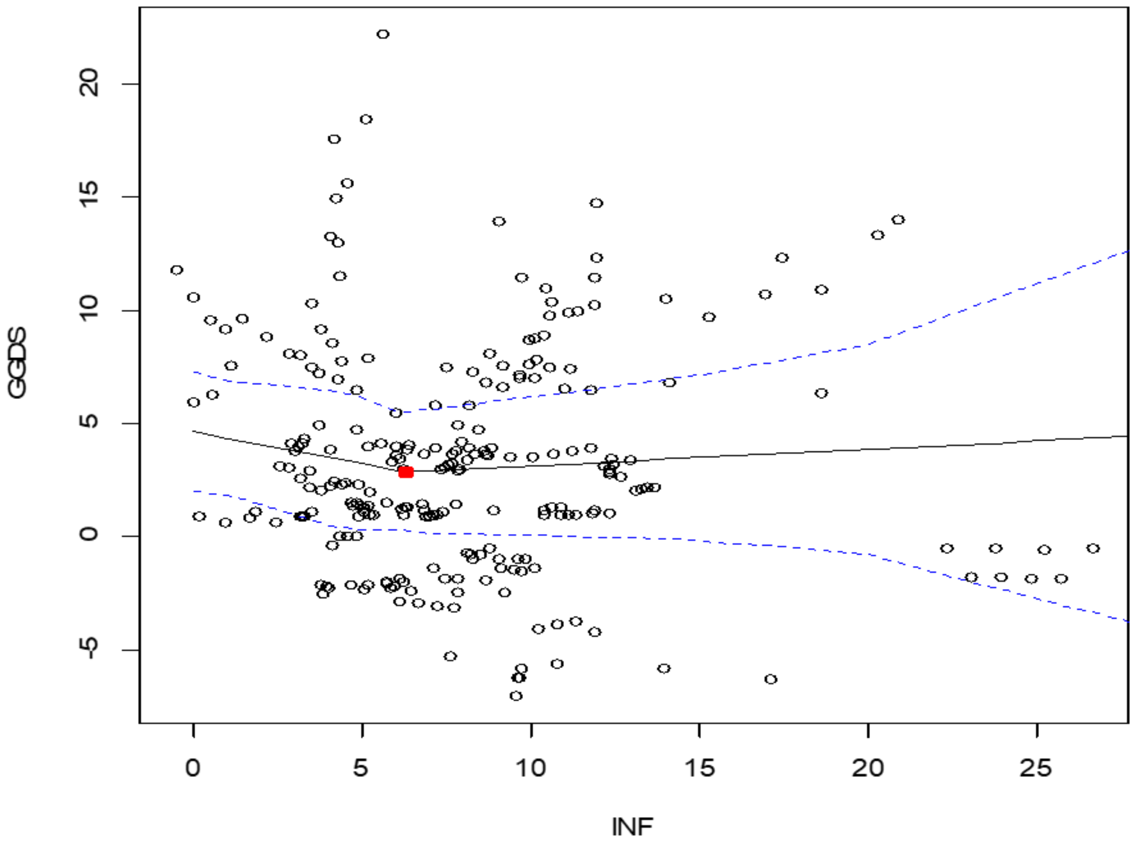


**Figure 4.2.3 Scatter plot of growth rate of gross domestic saving and Inflation, with estimated regression kink model, and 90% confidence intervals[14].**

[14] Source [ Author's work using Hansen(2017) R-Codes]

## 4.3. Estimation of the Kink Regression Model

Following the Hansen methodology, Figure 4.3 represents the least square criterion plotted against $\boldsymbol{\gamma}$. As a result, the function is minimized at $\boldsymbol{\gamma}$ = 6.3% so the threshold inflation is 6.3%.

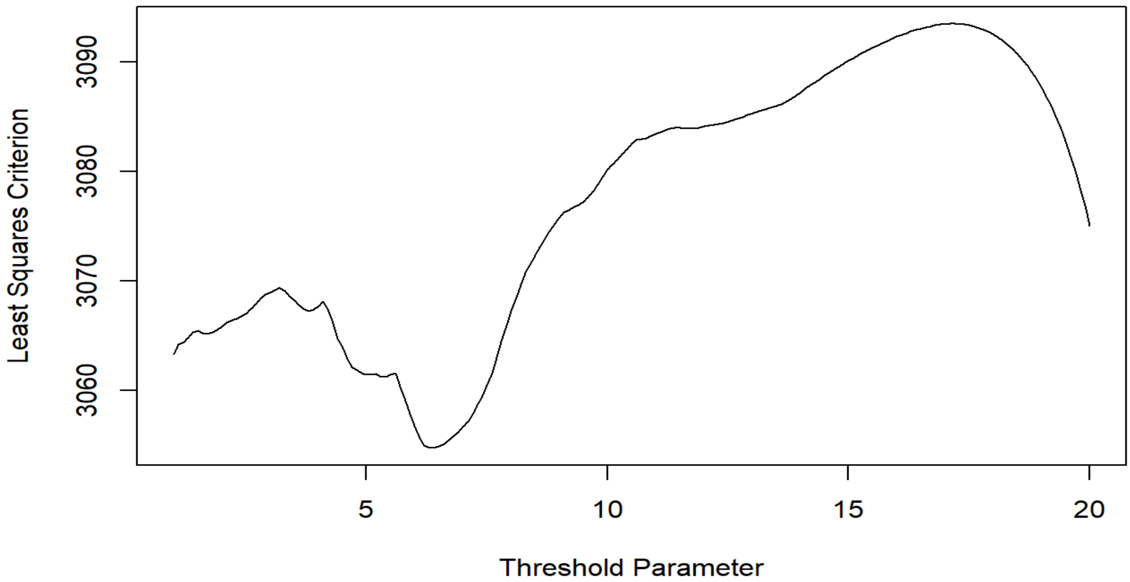


**Figure 4.3 Concentrated least-square criterion for threshold parameter.**

**Source [Author's work using Hansen (2017) R-Codes]**

Then, by applying the above-mentioned methodology, the estimated kink regression model is:

$$\boldsymbol{GGDS_t} = -0.34\,(\boldsymbol{INF_{t-1}} - \mathbf{6.3})_- + 0.06\,(\boldsymbol{INF_{t-1}} - \mathbf{6.3})_+ + 0.66\,\boldsymbol{GGDS_{t-1}}$$

$$-0.04\,\boldsymbol{GY_t} + 0.02\,\boldsymbol{GFI_t} + 0.05\,\boldsymbol{ADR_t} - 3.89 \qquad \mathbf{(4.1)}$$

$$\hat{\sigma}^2 = \mathbf{12.6}$$

The estimated equation (4.1) confirms the non-linearity as shown in Fig. 4.2.3.

According to equation (4.1), for every 1 percentage point increase in inflation above the 6.3 percent threshold, the growth rate of gross domestic savings increases by 0.06 percentage point as a proportion of GDP. When the inflation rate is less than 6.3 percent, a 1 percentage point increase in inflation reduces the growth rate of gross domestic savings by 0.34 percentage point as a proportion of GDP. The most recent growth rate of gross domestic savings raises the current rate by 0.66 percentage points. Financial development and the age dependency ratio have a favorable effect on the growth rate of gross domestic savings. In contrast, the growth rate of income exerts a notably an adverse influence on the growth rate of gross domestic savings. A 1 percentage point increase in financial development (GFI) results in a 0.02 percentage point increase in the growth rate of gross domestic savings (GGDS), whereas a 1percentage point increase in the age dependency ratio (ADR) results in a larger 0.06 percentage point increase in GGDS. A 1 percentage point increase in the growth rate of income (GY), on the other hand, corresponds to a 0.05 percentage point drop in GGDS as a proportion of GDP. The interaction of the factors outlined below explains the inverse relationship between the growth rate of income and the growth rate of gross domestic saving. Income growth may result in higher nominal income; however, an eroding effect of inflation on real income value may cause people to allocate more income to consumption expenditure in order to compensate for the effects of inflation. As a result, less money is available for savings. In other words, an increase in income growth, particularly when combined with significant inflation, may result in increased consumption spending in order to maintain purchasing power in an inflationary environment. As a result, savings rates may fall as more income goes to consumption to compensate for the effects of inflation.

## 4.4. Testing for Threshold Effect

$\boldsymbol{T_n = 3.8144}$ is the F statistical value. The multiplier bootstrap p-value is 0.09. Because the p-value $p_n$= 0.09 is less than 10%, so rejects the null hypothesis of linearity in favor of the regression kink model. Similarly, at the 10% significance level, the null hypothesis is rejected because the bootstrap-derived 10% critical value, which is 3.7812, falls below the F statistic value of $\boldsymbol{T_n = 3.8144}$. As a result, the test rejects the null hypothesis of linearity at the 10% level and supports the concept of the regression kink model.

## 4.5. Inference on the Regression Coefficients

In Figure (4.5), the statistic $F_n(\gamma)$ from equation (4.5) is plotted against threshold parameter $(\gamma)$. The graph includes a blue dashed line that represents the asymptotic 90% critical value, $c_{0.9}$ which is equal to 2.7.

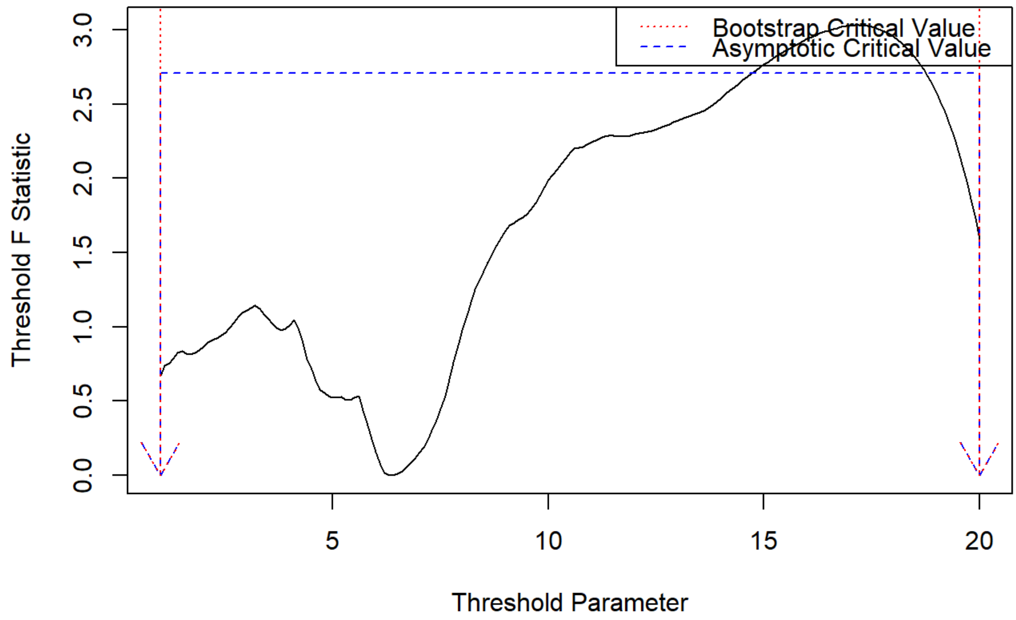


**Figure 4.5 Confidence Interval Construction for Threshold**[15]

The blue dashed arrows extending to the horizontal axes represent the boundaries of the asymptotic confidence interval. A red dotted line indicates the bootstrap 90% critical value of

[15] Source [ Author's work using Hansen(2017) R-Codes]

4.556, which was computed using 10,000 bootstrap replications. The confidence interval ranges are represented by the red dotted arrows reaching the horizontal axis.

The null hypothesis is rejected because the bootstrap critical value of the F-test, which is 4.556, is greater than the asymptotic critical value of the F-test, which is 2.7. This finding confirms the significance of the threshold parameter, indicating a presence of threshold effect in the model. Table 4.5 lists the estimated coefficients and their confidence intervals as derived through bootstrap method. In comparison to Hansen (2017), where the 90% confidence interval for the threshold parameter (γ) is estimated to be between 31% and 70%, this study's narrow 90% confidence interval ranges from 1.00 to 20.00. This suggests that the threshold effect is estimated with sufficient certainty. The 90% confidence interval for INF (after threshold) is wide, [-0.469, 0.602]. The broad confidence interval, according to Hansen (2017), may be due to the small sample size.

**Table 4.5 (3) Coefficient Estimates and Bootstrap 90% Confidence Intervals**

| | **Estimate** | **Confidence Interval** |
|---|---|---|
| **INF (Before Threshold)** | -0.34 | [ -0.80, 0.11] |
| **INF (After Threshold)** | 0.06 | [-0.47, 0.60] |
| $\boldsymbol{GGDS_{t-1}}$ | 0.66 | [0.56, 0.75] |
| **ADR** | 0.05 | [0.00075, 0.104] |
| **GY** | -0.04 | [-0.23, 0.15] |
| **GFI** | 0.02 | [-0.04, 0.08] |
| **Intercept** | -3.84 | [-8.29, 0.60] |
| $\boldsymbol{\gamma}$ | 6.30 | [1.00, 20.0] |

Source [Author's work using Hansen (2017) R-Codes]

## 4.6. Results Discussion

Based on the estimation and discussion above, the results of the F-test suggest that the regression kink model is significant. Additionally, the significance of the threshold parameter indicates the presence of a threshold effect in the model. The results reveal a non-linear relationship characterized by a U-shaped pattern (Figure 4.2.3) between INF and the GGDS, indicating that the direction of the inflation-saving relationship varies before and after the 6.3% inflation threshold. Thus, it is evident that inflation exerts a non-linear impact on the GGDS.

Similarly, Krishnamurthy and Saibaba (1981) investigated non-linear relationship between inflation and saving for India. According to the study's findings, there is linear relationship between inflation and saving in India.

But, the findings of this study, revealing a U-shaped relationship between inflation and saving, can be explained by examining different stages of individuals' saving behavior in response to varying levels of inflation.

The observed U-shaped relationship between inflation and saving indicates a complex interaction between these variables. Initially, as inflation rises, people may perceive a drop in the real worth of their savings, prompting them to reduce their saving behavior in order to maintain purchasing power. This declining trend corresponds to the usual expectation. However, above a threshold at high inflation, the relationship reverses, showing an increase in saving rates despite ongoing inflationary pressures. This reversal could be attributed to a variety of factors, including heightened uncertainty about future economic conditions or a shift in consumer preferences towards saving as a precaution against inflation. Saving rates may rise again during this period to protect against the detrimental impacts of inflation.

In summary, the U-shaped relationship between inflation and saving is justified by the fluctuating dynamics of individuals' saving behavior at varying levels of inflation. Initially, as inflation rises, individuals reduce saving to preserve purchasing power. Beyond a threshold at high inflation, saving rates increase despite continued inflation, possibly due to factors like economic uncertainty or a preference for precautionary saving.

# CHAPTER 5

# CONCLUSION

This study employed the Hansen (2017) methodology. The findings revealed a threshold inflation rate of 6.3%. This means that there is a significant change in the relationship between inflation and savings when inflation crosses this threshold. Below this threshold, a 1 percentage point increase in inflation reduces the growth rate of gross domestic savings by 0.34 percentage points as a proportion of GDP. However, when inflation exceeds 6.3%, a 1 percentage point increase in inflation results in a 0.06 percentage point increase in the growth rate of gross domestic savings as a proportion of GDP and the most recent growth rate of gross domestic savings also positively influences the current rate, increasing it by 0.66 percentage points.

The findings provide evidence for a non-linear relationship. Findings show a U-shaped, non-linear relationship between inflation and growth rate of gross domestic savings. At first, as inflation rises, people might realize a drop in the real value of their savings, leading them to reduce their saving in order to maintain purchasing power. However, above a threshold, the relationship changes, the savings rising with persisting inflationary pressures. This change could be linked to the fact that a very high inflation rates induce a precautionary savings approach due to the uncertainties and instability caused by rapid price increases, resulting in an increase in saving rates.

The study's findings contribute to the understanding of the complex relationship between inflation and savings. It highlights the presence of a threshold inflation rate.

In conclusion, the study has figured out U-shaped relationship between inflation and saving, with a threshold of 6.3%. Given the current high inflation rate of around 9.50% in 2021 according to the World Development Indicators (WDI), individuals and businesses are finding it increasingly challenging to plan for the future. This is due to the excessively high and unpredictable nature of inflation rates.

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# APPENDIX

## Appendix-A Summary of Empirical Literature

| Title | Author | Country/ Time Period | Estimation Techniques | Conclusions |
|---|---|---|---|---|
| Inflation and Saving: A puzzle | Mose and Thomi (2022) | Kenya / (1975-2020) | OLS | Savings are positively associated to inflation. 1% rise in inflation corresponds to a 0.75% increase in the saving rate. |
| Determinants of National Saving: Evidence from South Asian Countries | Khan et al. (2017) | Six South Asian countries / (1989 -2013) | Panel data | Inflation has a significant positive impact on gross domestic savings. |
| Saving Behavior In Malaysia: An Empirical Study | Cheng and li (2008) | Malaysia / (1980 - 2006) | OLS | Inflation has a positive influence on Malaysian national saving |
| Short Run and Long Run Saving | Chaudhry et al. (2010) | Pakistan / (1972 - | Johansen Co-integration and | Inflation had a long run positive |

| | | | | |
|---|---|---|---|---|
| Behavior in Pakistan: An Empirical Investigation | | 2008) | Vector Error Correction Model | and significant influence on national savings |
| A Time Series Analysis of the determinants of Savings in Namibia | Ogbokor and Samahiya (2014) | Namibia / (1991 to 2012) | Co-integration and error correction model | Inflation has a positive influence on savings |
| The saving-inflation puzzle: explaining their relationship in Ethiopia. | Taye (2017) | Ethiopia / (1974 - 2014) | Autoregressive distributed lag (ARDL) bounds testing technique | In the long run inflation has a considerable positive influence on national saving in the long run but a negligible effect in the short run |
| The effect of interest rate, inflation rate and GDP on national savings rate | Abou El-Seoud (2014) | Kingdom of Behrain / (1993 - 2013) | Co-integration | The inflation rate has a significant positive influence on the national saving rate in both the short and long term. |
| The monetary and fiscal determinants | Chaudhry et al. (2014) | Pakistan / (1972 - | ARDL and ECM | Inflation rate has a positive association |

| | | | | |
|---|---|---|---|---|
| of national savings in Pakistan | | 2010) | | with national saving |
| Macro and socioeconomic determinants of Turkish private savings. | Ozcan et al. (2012) | Turkey / (1974 - 2008) | OLS | The inflation rate has a significant positive influence on the national saving. |
| Dynamics of Asian savings: the role of growth and age structure | Lahiri (1989) | Eight Asian Countries / (Different time periods for each country) | OLS | Inflation has a negative effect on private savings on average |
| Macroeconomic Determinants of Savings in Pakistan. | Shaikh and Sheikh (2013) | Pakistan / (1974 - 2009) | OLS and Prais-Winsten estimation approach | National savings rate is inversely connected to inflation. |
| The determinants of savings: Empirical evidence from Pakistan. | Aleemi et al. (2015) | Pakistan / (1980 - 2010) | ARMA specification | Inflation had a negative impact on the national savings rate. |
| Macroeconomic determinants of national savings revisited: A small | Ahmad and Mahmood (2013) | Pakistan / (1974-2010) | ADRL bound testing technique and ECM | Inflation rate had a negative influence on national savings |

| | | | | |
|---|---|---|---|---|
| open economy of Pakistan. | | | | |
| An Investigation of the Determinants of Savings and Investment in Nigeria | Adelakun (2015) | Nigeria | Error correction approach | Inflation rate had a negative influence on savings |
| Agricultural Output, Inflation Rate, Fiscal Deficit and National Savings Nexus: Evidence from Pakistan. | Sajid and Hafeez (2021) | Pakistan / (1973 - 2020) | ARDL model and ECM | Inflation rate has a negative impact on national savings in both the long and short term |
| Macro and socioeconomic determinants of savings in Pakistan. | Akram and Akram (2016) | Pakistan / (1973 -2013) | ARDL bounds testing technique | Inflation is inversely related connected to all three types of savings (national, public, and private) |
| Savings behaviour in Muslim and non-Muslim countries in context to the interest rate. | Akram and Akram (2015) | Four Muslim and Four non-Muslim-majority countries / | Panel technique | Inflation had a significant negative impact on savings in both categories of nations (Muslim |

| | | | | |
|---|---|---|---|---|
| | | (1975 - 2012) | | and Non-Muslim) |
| The effect of economic variables on national saving of Pakistan. | Rehan et al. (2019) | Pakistan / (1995Q1 - 2018Q4) | ARDL | Inflation had no effect on national saving in Pakistan |
| Determinants of savings in the APEC countries. | Aric (2010) | 16 APEC member countries / (2000 - 2013) | Panel data Fixed effect | Inflation has insignificant impact on savings in APEC nations |
| Factors Affecting the Rate of Gross Domestic Saving in Different Countries | . Khan et al. (2017) | Pakistan, China, Singapore, Japan, Turkey, and Russia / (1995 - 2016) | Panel technique Fixed effect | Inflation has insignificant impact on gross domestic savings |
| Determinants of saving rate in India | Krishnamurthy and Saibaba (1981) | India / (1952 - 1979) | OLS and weighted least squares (WLS) | Non-linear relationship between inflation and saving and existence of threshold |

| | | | | |
|---|---|---|---|---|
| Does inflation affect savings non-linearly? Evidence from India. | Dash & Kumar (2018). | India / (1970 - 2012) | Quadratic approach and Sarel technique | Inflation has a non-linear influence on saving. There is no threshold inflation |

## Appendix-B Codes of Hansen (2017)

```
# Load in Data
growth <- read.table("usdata.txt",header=TRUE)
n = nrow(growth)
year = growth[2:n,1]
gdp  = growth[2:n,3]
gdp1 = growth[1:(n-1),3]
debt1= growth[1:(n-1),2]
# Time-Series Data Plots, Figure 1ab in paper
windows()
plot(year,gdp,type="l",ylab="GDP Growth Rate")
savePlot(file="fig1a.eps",type="eps",dev.cur())
windows()
plot(year,debt1,type="l",ylab="Debt/GDP")
savePlot(file="fig1b.eps",type="eps",dev.cur())
# Define variables
y = gdp
x = debt1
n = length(y)
z = cbind(gdp1,matrix(1,n,1))
# Controls
gammas = seq(10,70,by=0.1) # Grid on Threshold parameter for estimation
dx = seq(0,121,by=1)       # Grid on regression function for display
level = 0.90               # For confidence sets
boot = 10000               # Number of bootstrap replications
Ceps = c(0.5,1,2,4)        # For numerical delta method bootstrap
```

```
######################################

# Some useful functions
reg <- function(X,y) {
  X <- qr(X)
  as.matrix(qr.coef(X,y))}
pos.part <- function(x) x*(x>0)
neg.part <- function(x) x*(x<0)

pt1 = proc.time()

# Linear Model
x0 = cbind(debt1,z)
k0 = ncol(x0)
kz = ncol(z)
x00 = solve(crossprod(x0))
bols = x00%*%crossprod(x0,y)
e0 = y - x0%*%bols
sse0 = sum(e0^2)
sigols = sse0/n
v0 = x00%*%crossprod(x0*matrix(e0,n,k0))%*%x00*(n/(n-k0))
seols = as.matrix(sqrt(diag(v0)))

# Threshold Model
  grid = length(gammas)
  rd = length(dx)
```

```
sse = matrix(0,grid,1)
k = kz + 3
for (j in 1:grid) {
  gamj=gammas[j]
  x1 = cbind(neg.part(x-gamj),pos.part(x-gamj),z)
  e1 = y - x1%*%reg(x1,y)
  sse[j] = sum(e1^2)}
gi = which.min(sse)
gammahat = gammas[gi]
ssemin = sse[gi]
x1 = cbind(neg.part(x-gammahat),pos.part(x-gammahat),z)
bt = reg(x1,y)
et = y - x1%*% bt
hg = - (x<gammahat)*bt[1] - (x>gammahat)*bt[2]
x2 = cbind(x1,hg)
hg2 = crossprod(cbind((x<gammahat),(x>gammahat)),et)
xx2 = matrix(0,k,k)
xx2[1:2,k]=hg2
xx2[k,1:2]=t(hg2)
xxi = solve(crossprod(x2) + xx2)
v = xxi%*%crossprod(x2*matrix(et,n,k))%*%xxi*(n/(n-k))
betahat = rbind(bt,gammahat)
se = as.matrix(sqrt(diag(v)))
sig = sum(et^2)/n
wt = n*(sse0-ssemin)/ssemin
wg = n*(sse-ssemin)/ssemin
```

```
# Plot Least Squares Criterion, Figure 3 in paper
windows()
plot(gammas,sse,type="l",ylab="Least Squares Criterion",xlab="Threshold Parameter")
savePlot(file="fig3.eps",type="eps",dev.cur())

# Regression Estimate
G = cbind(neg.part(dx-gammahat),pos.part(dx-gammahat),matrix(1,rd,1)%*%colMeans(z))
yf = G%*%bt

# Bootstrap & Testing
  waldb = matrix(0,grid,boot)
  sseb  = matrix(0,grid,boot)
  betab = array(0,c(grid,k-1,boot))
  u = matrix(rnorm(n*boot),n,boot)
  eb = matrix(e0,n,boot)*u
  yb = matrix(x1%*%bt,n,boot) + matrix(et,n,boot)*u
  eb0 = eb - x0%*%reg(x0,eb)
  bsse0 = colSums(eb0^2)
  for (j in 1:grid) {
    gamj = gammas[j]
    x2 = cbind(neg.part(x-gamj),pos.part(x-gamj),z)
    eb0 = eb - x2%*%reg(x2,eb)
    bsse = colSums(eb0^2)
    waldb[j,] = n*(bsse0-bsse)/bsse
    bb = reg(x2,yb)
    eb1 = yb - x2%*%bb
    sseb[j,] = colSums(eb1^2)
```

```
    betab[j,,] = bb }

# Multiplier Bootstrap test for Threshold
  wb = apply(waldb,2,max)
  pv = mean(wb > matrix(wt,boot,1))
  crit = quantile(wb,probs=level)

# Threshold Regression Estimates
  gib = apply(sseb,2,which.min)
  gamb = gammas[gib]

# Symmetric Percentile Confidence Interval Construction
  betahatb = matrix(0,k-1,boot)
  ci = matrix(0,k,2)
  for (j in 1:(k-1)){
    bj = diag(betab[gib,j,])-bt[j]
    qj = quantile(abs(bj),probs=level)
    ci[j,1] = bt[j] - qj
    ci[j,2] = bt[j] + qj
    betahatb[j,] = t(bj) }

# Confidence Interval for Threshold
  sseb0 = colSums((yb - x1%*%reg(x1,yb))^2)
  sseminb = apply(sseb,2,min)
  wgb = n*(sseb0-sseminb)/sseminb
  qa = qchisq(level,1)
  wia = (wg > qa)
```

```
  cga = c(gammas[which.min(wia)],gammas[grid+1-which.min(rev(wia))])

  qb = quantile(wgb,probs=level)

  wib = (wg > qb)

  cgb = c(gammas[which.min(wib)],gammas[grid+1-which.min(rev(wib))])

  ci[k,] = cgb


# Threshold Regression Confidence Intervals

  mdx = t(matrix(dx,rd,boot))-gammahat

  thetab = t(G%*%betahatb)

  cn = length(Ceps)

  yf1 = matrix(0,rd,cn)

  yf2 = matrix(0,rd,cn)

  for (j in 1:cn) {

    eps = Ceps[j]

    h = matrix(gamb-gammahat,boot,rd)*eps

    thetaq = thetab + ((neg.part(mdx-h)-neg.part(mdx))*bt[1] + (pos.part(mdx-h)-
pos.part(mdx))*bt[2])/eps

    qf = apply(abs(thetaq),2,quantile,probs=level)

    yf1[,j] = yf - qf

    yf2[,j] = yf + qf  }


pt2 = proc.time()


sink("growth.out")

cat("Linear Model, coefficients and error variance","\n")

print(cbind(bols,seols),digits=2)

cat("Error variance","\n")
```

```
print(sigols,digits=4)


cat("Wald Test for Threshold, p-value, & critical value","\n")
print(c(wt,pv,crit,level),digits=3)
cat("Threshold Model Estimates, s.e.'s, and Bootstrap confidence intervals","\n")
print(cbind(betahat,se,ci),digits=2)
cat("Error variance","\n")
print(sig,digits=4)

cat("Bootstrap Critical value for threshold parameter interval",qb,"\n")
cat("Computation Time: replications and seconds","\n")
print(c(boot,pt2[3]-pt1[3]),digits=3)

sink()

# Plot Confidence Interval Construction for Threshold (Figure 4)
windows()
plot(gammas,wg,type="l",ylab="Threshold F Statistic",xlab="Threshold Parameter")
cr1 = matrix(qa,grid,1)
cr2 = matrix(qb,grid,1)
lines(gammas,cr1,lty="dashed",col="blue")
lines(gammas,cr2,lty="dotted",col="red")
arrows(cga[1],qa,cga[1],0,lty="dashed",col="blue")
arrows(cga[2],qa,cga[2],0,lty="dashed",col="blue")
arrows(cgb[1],qb,cgb[1],0,lty="dotted",col="red")
arrows(cgb[2],qb,cgb[2],0,lty="dotted",col="red")
```

```
legend("topright",c("Bootstrap Critical Value","Asymptotic Critical Value"),lty=c("dotted","dashed"),col=c("red","blue"))

savePlot(file="fig4.eps",type="eps",dev.cur())


# Scatter plot, regression line, and confidence intervals (Figure 2)

windows()

plot(debt1,gdp,ylab="GDP Growth Rate",xlab="Debt/GDP")

lines(dx,yf)

lines(dx,yf1[,2],lty="dashed",col="blue")

lines(dx,yf2[,2],lty="dashed",col="blue")

yk = colMeans(z)%*%bt[3:(2+kz)]

points(gammahat,yk,col="red",bg="red",pch=22)

savePlot(file="fig2.eps",type="eps",dev.cur())


windows()

plot(dx,yf,ylab="GDP Growth Rate",xlab="Debt/GDP",type="l",ylim=c(-8,8),yaxt="n")

axis(2,at=c(-8,-4,0,4,8))

lines(dx,yf1[,1],lty="dashed",col="orange")

lines(dx,yf2[,1],lty="dashed",col="orange")

lines(dx,yf1[,2],lty="dotted",col="red")

lines(dx,yf2[,2],lty="dotted",col="red")

lines(dx,yf1[,3],lty="dashed",col="blue")

lines(dx,yf2[,3],lty="dashed",col="blue")

lines(dx,yf1[,4],lty="dotted",col="black")

lines(dx,yf2[,4],lty="dotted",col="black")

points(gammahat,yk,col="red",bg="red",pch=22)

leg1 = bquote(paste(epsilon[n]==.(Ceps[1]),n^-.5))
```

```
leg2 = bquote(paste(epsilon[n]==.(Ceps[2]),n^-.5))

leg3 = bquote(paste(epsilon[n]==.(Ceps[3]),n^-.5))

leg4 = bquote(paste(epsilon[n]==.(Ceps[4]),n^-.5))

leg_text = c(as.expression(leg1),as.expression(leg2),as.expression(leg3),as.expression(leg4))


legend("bottomleft",leg_text,lty=c("dashed","dotted","dashed","dotted"),col=c("orange","red
","blue","black"))

savePlot(file="fig7.eps",type="eps",dev.cur())

##############################################
```

## Appendix-C Correlation Matrix

| | Deposit interest rate (%) | Inflation, consumer prices (annual %) | Lending interest rate (%) | Interest rate spread (lending rate minus deposit rate, %) | Real interest rate (%) |
|---|---|---|---|---|---|
| Deposit interest rate (%) | 1.000 | 0.455 | 0.823 | -0.155 | -0.125 |
| Inflation, consumer prices (annual %) | 0.455 | 1.000 | 0.646 | 0.401 | -0.503 |
| Lending interest rate (%) | 0.823 | 0.645 | 1.000 | 0.434 | -0.189 |
| Interest rate spread (lending rate minus deposit rate, %) | -0.155 | 0.401 | 0.434 | 1.000 | -0.132 |
| Real interest rate (%) | -0.125 | -0.503 | -0.189 | -0.132 | 1.000 |