IBN HALDUN UNIVERSITY
SCHOOL OF GRADUATE STUDIES
DEPARTMENT OF ECONOMICS

MASTER THESIS

THE ROLE OF MONETARY POLICY AND FINANCIAL DEVELOPMENT IN ENSURING TECHNOLOGICAL PROGRESS AND THEIR ECONOMIC EFFECTS

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THESIS SUPERVISOR
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ISTANBUL, 2024

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by
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A thesis submitted to the School of Graduate Studies in partial fulfillment of the requirements for the degree of Master of Arts in Economics

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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ÖZ

PARA POLİTİKASI VE FİNANSAL KALKINMANIN TEKNOLOJİK İLERLEMEYİ SAĞLAMADAKİ ROLÜ VE EKONOMİK ETKİLERİ

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Yeni ve geliştirilmiş ürün, süreç, hizmet veya iş taktiklerinin yaratılması ve benimsenmesi -toplu olarak teknolojik yenilik olarak bilinir- toplum için faydalar sağlar ve şirketlerin ekonomik verimliliğini ve rekabet gücünü artırır. Sonuç olarak, teknolojik yeniliği yönlendiren faktörleri anlamak, sürdürülebilir kalkınmayı sağlamak ve ekonomik büyümeyi teşvik etmek için çok önemlidir. Para politikası, kısa vadeli faiz oranları sıfıra ulaşmış olsa bile, teknolojik yeniliği ve zayıf bir ekonomiyi etkili bir şekilde teşvik eder. Finansal piyasaların iyi işlemesi, para politikalarının iletimini artırır ve gelişmekte olan ülkeler arasında yeniliğe yol açabilir. Çalışma, ARDL modelini kullanarak BRICS ülkeleri için para politikasının ve finansal gelişimin teknolojik yenilik üzerindeki etkisini araştırmayı amaçlamaktadır. Önceki çalışmalar teknolojik yeniliği ölçmek için Ar-Ge ve TFP değişkenlerini kullanırken, bu araştırma ampirik analizinde üç farklı yenilik göstergesi kullanmaktadır: ikamet edenler, ikamet etmeyenler ve teknolojik yenilik ayrı ayrı. ARDL modeli, uzun vadeli ve kısa vadeli değişken bağlantıları ve politika sonuçlarını analiz etmek için yaygın olarak kullanılır. Çalışmanın bulguları birkaç değerli sonuç sunmaktadır. Birincisi, gevşek para politikası yerleşikler arasında inovasyonu büyük ölçüde artırır ve bu önlemler uzun vadede iyi gelişmiş finansal piyasalar ve kısa vadede karmaşık ilişkiler nedeniyle yaratıcılığı büyük ölçüde artırır ve teknolojik inovasyonu önemli ölçüde

iyileştirir. İkincisi, daraltıcı para politikasının yerleşik olmayanlar arasındaki etkisi karmaşıktır. Proaktif müdahale ve daha düşük oynaklığa sahip, istikrarlı büyümeyi destekleyen gelişmekte olan ülkeler, daraltıcı para politikasıyla inovasyonu teşvik eder ve finansal gelişme her zaman inovasyonla olumlu ilişkilidir. Her ikisi de ekonominin uzun vadeli sürdürülebilirliğini sağlamak için kritik öneme sahiptir. Bulgular ayrıca esnek bir para politikasının teknolojik inovasyonla ilgili faaliyetler üzerinde önemli bir olumlu etkiye sahip olduğunu göstermektedir. Son olarak, yüksek enflasyon ve faiz oranları yaşayan ülkeler bireyler arasında finansal bağımsızlığı teşvik etme eğilimindedir ve banka kredilerine olan bağımlılıklarını azaltır.

Anahtar Kelimeler: Finansal Gelişme, Para Politikası, Teknolojik Yenilik.

ABSTRACT

THE ROLE OF MONETARY POLICY AND FINANCIAL DEVELOPMENT IN ENSURING TECHNOLOGICAL PROGRESS AND THEIR ECONOMIC EFFECTS

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The creation and adoption of novel and improved products, processes, services, or business tactics—collectively known as technological innovation—provide benefits for society and boost the economic efficiency and competitiveness of companies. Consequently, understanding the factors that drive technological innovation is crucial for achieving sustainable development and fostering economic growth. Monetary policy effectively stimulates technological innovation and a weak economy, even when short-term interest rates have already reached zero. Well-functioning of financial markets enhances the transmission of monetary policies and can lead to innovation among emerging countries. The study aims to investigate the impact of monetary policy and financial development on technological innovation for BRICS countries using the ARDL model. While previous studies employed R&D and TFP variables to measure the technological innovation, this research uses three different innovation indicators in its empirical analysis, namely patent application by residents, non-residents, and technological innovation separately. ARDL model is commonly used to analyze long-term and short-term variable connections and policy outcomes. The findings of the study provide several valuable results. First, loose monetary policy greatly enhances innovation among residents, and these measures greatly boost inventiveness and significantly improve technological innovation due to well-

developed financial markets in the long run and mixed relationships in the short run. Secondly, the impact of contractionary monetary policy among non-residents is mixed. Emerging countries with proactive intervention and lower volatility, which have supported stable growth, promote innovation with contractionary monetary policy, and financial development is always positively related to innovation. Both are critical to ensuring the long-term viability of the economy. The findings also indicate that having a flexible monetary policy has a significant positive influence on activities related to technological innovation. Lastly, countries experiencing high inflation and interest rates tend to foster financial independence among individuals, reducing their reliance on bank loans.

Keywords: Financial Development, Monetary Policy, Technological Innovation.

DEDICATION

I dedicate my thesis to my family, whose unwavering support and encouragement have continually bestowed upon me strength and motivation. I express my appreciation to my mentor and instructors for their essential assistance throughout this journey.

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I express my thankfulness to Allah Almighty for bestowing upon me robust health and an unwavering will to start and successfully finish my thesis.

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LIST OF SYMBOLS AND ABBREVIATIONS

CB	Central Bank
DCPS	Domestic Credit Private Sector
EG	Economic Growth
ER	Exchange Rate
FD	Financial Development
GDPG	Gross Domestic Product Growth
GDPC	Gross Domestic Product Per Capita
INN	Innovation
IR	Interest Rate
MP	Monetary Policy
RII	Real Interest Rate
SMEs	Small and Medium Enterprises

CHAPTER I

INTRODUCTION

1.1. Background of the Study

In an era characterized by rapid technological advancements, globalization, and dynamic economic landscapes, the nexus between innovation and monetary policy has emerged as a critical area of inquiry and policy consideration. Innovation is seen to be essential to economic growth. The production or adoption of new or improved products, processes, services, or business models can create value for society and enhance the economic performance and competitiveness of organizations. Innovation is crucial for a country's long-term economic development and competitive edge; motivating individuals and creating a conducive climate for fostering innovation may be rather challenging (Solow, 1957). The ability of economies to generate and commercialize new ideas, technologies, and processes not only fosters productivity gains but also enhances their resilience to economic shocks and global challenges. Against this backdrop, policymakers worldwide have increasingly recognized the importance of fostering innovation-led growth to sustain long-term prosperity. Holmstrom (1989) highlights that the invention process is not only drawn out, unique, and unpredictable, but also carries a high risk of failure.

Concurrently, as central banks adjust monetary policy (MP) to achieve macroeconomic goals like price stability, inflation, and employment. It unintentionally affects innovation by affecting capital costs, credit availability, investor confidence, and risk-taking. Central banks' monetary policy affects macroeconomic circumstances, financial growth, stability, and investment incentives. (R&D), entrepreneurship, and technology adoption are affected by central banks' interest rates, money supply, and credit conditions. Bernanke and Bernanke (1992) highlight that monetary policy significantly impacts real economic activity, with changes in interest rates affecting aggregate demand and investment decisions. Monetary policy changes aggregate

demand, innovation profitability, financial market circumstances, loan availability, which effect entrepreneurial activity, and startup innovation. Price stability and avoiding unexpected price changes are long-term goals of monetary policy. In nations, central policy decisions strongly impact company incentives and innovation. Lower interest rates reduce capital costs and increase R&D investment, whereas tougher monetary policy may limit financing and innovation.

These monetary policy adjustments, manifested through changes in interest rates, credit market conditions, and exchange rate dynamics, can either stimulate or dampen investment in innovation by firms, entrepreneurs, and investors. Innovation typically requires a significant level of financial expenditure; thus, it is heavily dependent on the accessibility of financial resources. Hence, the MP stance can influence corporate innovation by imposing financial constraints. Specifically, when monetary policy is tightened, credit limits for enterprises are exacerbated, leading to a decrease in inventive activity. MP also impacts firms' motivations to create and execute innovations through alternative means. There is a limited but increasing amount of research that focuses on the potential long-term effects of MP. These effects occur through the impact of MP on innovation and technological advancement. (Fornaro, 2023). MP contraction can diminish the profitability of creating new items and motivation to innovate by reducing demand (Shleifer, 1986; Fatás & Singh, 2024).

Monetary policy and financial development are interconnected, since successful monetary policies provide a stable economic climate that promotes investment and growth in financial markets. Schumpeter (1911) asserts that the formation of financial markets is crucial for a nation's innovation and the implementation of MP. Well-developed financial markets enhance the transmission of MP, improving its effectiveness in achieving economic objectives like controlling inflation and stimulating growth. To effectively promote innovation, it is necessary to have financial markets that are functioning well. These markets have important responsibilities in reducing the costs of financing, allocating limited resources, appraising new ventures, controlling risk, and monitoring management. Thus, encouraging innovation successfully also requires well-operating financial markets and financial markets that have crucial functions in transmission of monetary policy, decreasing financing costs,

distributing limited resources, assessing new enterprises, handling risk, and supervising management (Holmstrom, 1989).

The availability and cost of financing in financial markets drive research and development, technology adoption, and entrepreneurial ventures, facilitating innovation. Credit assists SMEs in surmounting financial limitations and fostering innovation. The availability of market financing affects the risk-taking and creativity of businesses and investors. It also follows that studies indicate liquid, deep, and well-diversified financial markets, with strong investor protection, may facilitate the flow of funds to innovative firms and projects. According to Levine (2005), monetary policy shapes conditions in financial markets and, as a result, affects the supply of finance available and its cost by influencing interest rates, lending standards, and risk appetite. It will avoid risky and uncertain research and development projects, where returns are also highly uncertain. Lending availability and cost effect innovation, especially for SMEs, which foster technological advancement and entrepreneurship. Transmission of monetary policy requires a developed financial market.

The connection between government subsidies and enterprises' R&D expenditure suggests that monetary policy affects this relationship via credit constraints and signal transmission (Bravo-Biosca et al., 2013). The lack of government support shifts the attention of investors towards the finance and credit markets. Under a stringent MP, financial institutions would decrease their willingness and the quantity of lending, leading to a rise in the cost of acquiring money. This makes the corporation less attractive to innovative investments due to their unpredictable return and risk as costs increase (Trinnugrooho et al., 2021).

The expansion of the credit market tends to increase RTI (technological innovation rate) by recognizing entrepreneurs who have a high probability of effectively inventing new products and industrial processes. An enhanced financial system reduces the ambiguity caused by unequal access to information, enabling financial intermediaries to choose the most favorable innovation projects. Furthermore, the advancement of the credit market is believed to impede innovation activities due to improved access to information and the reluctance of financial intermediaries to provide funding to new, creative companies.

Patents serve as a significant measure of technical advancement and originality, while DCPS indicates the accessibility of financial assets that enterprises might utilize for expansion and progress and real interest rate and broad money as a proxy of MP. Through an examination of this connection, we may get valuable knowledge about the influence of credit availability on the pace of innovation, as well as the reciprocal effect of technical progress on the dynamics of the financial sector. The aim of this research is to clarify the association between these factors, providing vital insights for policymakers to create an environment that promotes both financial stability and technical growth.

1.2. Significance of the Study

The interplay between these three domains, innovation, monetary policy, and financial development, underscores their intrinsic relationship and mutual impact on shaping the trajectory of economic development and prosperity. Despite growing recognition of the nexus between monetary policy and innovation, empirical research on this relationship remains comparatively new and characterized by complex interactions that need more investigation. The intent of this research is to elucidate the correlation among these factors, providing vital insights for policymakers to create an environment that promotes both financial stability and technical growth.

Innovation drives economic growth by introducing new technologies and improving productivity. Patent spending is a crucial indicator of a country's commitment to innovation and technological advancement. Aghion et al. (2005) demonstrate that innovation, spurred by R&D investments, significantly contributes to economic growth (EG) and productivity improvements. Bloom et al. (2019) found that increases in patenting activity are associated with higher future productivity and EG. Innovation is undersupplied due to high externalities (Bloom et al., 2013). Innovation downturns have negative effects. Bianchi et al. (2019) suggest that the 2001 recession could have contributed to persistent growth slowdown. Nanda and Rhodes-Kropf (2013) suggest that VCs fund companies that are riskier but more innovative in hot markets instead of systematically making wasteful investments.

Monetary policy plays a role in shaping financial market dynamics through its impact on interest rates, exchange rates, credit conditions, and risk-taking behaviors, thereby influencing the availability and cost of innovation financing (Aghion et al., 2018). Monetary policy can effectively stimulate a weak economy, even when short-term IR has already reached zero. It stabilizes the economy by controlling inflation, managing employment levels, and influencing interest rates. It provides a predictable economic environment that fosters investment and growth. Under a stringent monetary policy, financial institutions would decrease their willingness and the quantity of lending, leading to a rise in the cost of acquiring money. Consequently, corporations will be less inclined to participate in hazardous and uncertain research and development activities with unpredictable returns. According to Bernanke and Blinder (1992), monetary policy significantly impacts real economic activity, with changes in interest rates affecting aggregate demand and investment decisions. Innovation initiatives face significant risks of failure and extensive research and development periods, requiring consistent financial backing and governmental support (Habib et al., 2019).

MP plays a role in shaping financial market dynamics through its impact on interest rates, credit conditions, and risk-taking behaviors, thereby influencing the availability and cost of innovation financing (Aghion et al., 2019). Benmelech and Bergman (2012) show that firms with better access to credit engage more in innovative activities, as they can finance the upfront costs of R&D. A credit market with ample liquidity, competitive interest rates, and effective capital allocation allows SMEs the financial resources and confidence to innovate and compete in dynamic markets. Nanda and Nicholas (2014) highlight that credit constraints significantly hinder innovation, especially for SMEs and startups reliant on external financing. The accessibility and affordability of loans in the financial system are essential in promoting innovation by providing firms with the necessary funding for R&D, technology adoption, and entrepreneurial ventures.

Well-functioning financial markets, characterized by deep liquidity, diverse funding sources, and robust investor protection mechanisms, can facilitate innovation by channeling capital to innovate firms and projects (Levine., 2005). The changes have a direct impact on the environment of financing for enterprises and people, impacting their ability to innovate through credit constraints and signal transmission. Under tight

monetary policy, financial institutions reduce lending willingness and amounts, increasing the cost of raising funds and thereby reducing firms' willingness to invest in risky R&D activities (Yuhan & Yang, 2023). The absence of government financial assistance will increase firms' reliance on credit finance and alternative methods.

1.3. Objective of the Study

This thesis seeks to analyze the connection among technological innovation using three different innovation measures and checking differently for each, e.g., patent applications by residents and non-residents, and then the sum of both donated by Technological Innovation, MP, and FD in the BRICS countries from 1980 to 2021. Furthermore, to determine if the growth of financial markets and expansionary MP results in improving innovation. This research distinguishes itself from others by assessing the individual effects of MP and FD on innovation and by examining the variations between residents and non-residents via the use of different control variables. The objective is to ascertain the presence of a correlation, whether short-term or long-term. The differing degrees of CB independence and the protection of property rights in developing nations lead to diverse transmission effects. The objective is to contribute to the importance of MP for the achievement of development and EG in the developing countries. These countries were selected based on their growing economic significance, public acknowledgment, and potential future obstacles. The goal is to ascertain if there is any disparity between developing nations according to independence and GDP.

The study employed the ARDL model framework, incorporating lagged effects, for data analysis. The ARDL method demonstrates resilience and possesses a versatile structure that treats all parameters as endogenous variables. It has evolved into a widely used tool for analyzing variable interactions and the impacts of essential policy decisions. ARDL offers several benefits, such as the capacity to tackle endogeneity concerns and improve the efficiency of the estimate process, flexibility in lags and determining long-run relationships without having new equations, handling endogeneity and bound tests for cointegration, and flexibility in lag selection.

1.4. Gap in the Literature

Research examining the relationship between innovation and monetary policy, along with its connection to financial development, remains limited. Although certain studies have employed R&D expenditures and TFP (total factor productivity) as a proxy for assessing the influence of innovation, MP shocks, and uncertainty at the national level, these studies frequently fail to thoroughly analyze the interaction between technological innovation and different aspects of monetary policy, particularly in relation to financial development.

The predominant emphasis of current literature on the subject is on developed and developing economies, where data is more easily accessible and the economic conditions are more stable. Nevertheless, the interaction of the correlation between innovation and MP in emerging nations has not been well investigated. Developing economies exhibit distinct financial structures, capital accessibility, and regulatory frameworks that may affect the effect of MP on innovation. Specifically, in these nations, the restricted availability of priced loans and underdeveloped financial markets could hinder the capacity of companies, especially SMEs and startups, to engage in innovation. The absence of research on this topic is noteworthy, as comprehending the reaction of innovation to MP in emerging nations might provide useful perspectives for policymakers seeking to promote technological progress in less developed economies.

Most research has been conducted to investigate the connection among loose monetary policy and patent applications in specific countries. Nevertheless, there is an absence of research that examines the relationship between patents filed by residents and non-residents as a measure of technological innovation and financial development, along with various factors of MP. Patents are valuable for assessing technological innovation since they not only quantify the output of invention but also gauge the efficiency with which an organization utilizes its innovation resources (Fang et al., 2014). Nevertheless, the current body of research fails to sufficiently examine the interaction between certain categories of patents (such as green patents vs. general technical patents) and MP, especially in the context of differing levels of financial growth.

There is a lack of knowledge in the literature on the complex relationships between MP factors (such as interest rates, money supply, and inflation rates) and innovation results across time. Most of the research uses static models that fail to include the dynamic characteristics of this interaction. The significance lies in the fact that the impact of MP on innovation may not be instantaneous and might fluctuate across various time periods owing to problems such as policy delays, fluctuations in economic cycles, or changes in investor confidence. Utilizing dynamic econometric methods, such as the (ARDL) model, it provides a more detailed comprehension of the temporal development of these linkages, particularly in varied economic settings such as the BRICS nations.

There is a lack of study that considers the influence of global elements, such as international trade policies, exchange rate changes, and cross-border capital flows, on the relationship between innovation and MP. In an interconnected society, these concerns may have significant consequences for the financing and development of innovation. Exchange rate variations may impact the expenses associated with imported research inputs, while international trade rules can either impede or facilitate the spread of breakthrough technology.

This study aims to address these gaps by using a broader set of variables and adopting a dynamic approach to model the interactions between innovation, MP, and financial development. By focusing specifically on the BRICS countries, this research provides a unique perspective on how emerging economies, with their distinctive financial systems and policy environments, navigate the complex relationships between monetary policy and innovation. The study will utilize alternative measures of monetary policy and consider additional variables related to financial development, startup financing, and sectoral heterogeneity, employing the ARDL model and VECM to capture both short-term and long-term dynamics.

By doing so, this research will contribute to a more comprehensive understanding of the conditions under which monetary policy can effectively stimulate or hinder innovation, providing valuable insights for policymakers in developing and emerging countries.

1.5. Hyphothesis of the Study

According to the literature review, various hypotheses can be formulated regarding the relationship between MP, innovation, and FD. The first hypothesis of the study is that expansionary monetary policy positively influences technological innovation. The second hypothesis is that an increase in financial credit market development leads to greater technological innovation and transfers the effect of loose MP. The third hypothesis posits that the transmission of expansionary MP, which leads to innovation, is hindered by less developed financial markets, a low degree of central bank independence, and poor property rights in emerging countries. The final objective or hypothesis is that low interest rates in less developed markets do not affect innovation.

Monetary Policy (MP) is based on the idea that the IR plays a vital role in transmitting MP. Modifications in MP have a direct effect on the IR, which in turn impacts the rate of return on investment. As a result, this impacts the investment choices made by companies. Research supports the channel hypothesis, indicating that the MP directly influences R&D investment. The primary impact on R&D investment is its influence on investment efficiency. Bank credit strongly connects to commercial credit, which serves as a solution to the issue of inadequate distribution to enterprises (Han, 2022).

The reciprocal relationship between financial market development and innovation leads to a casual effect. Schumpeter (1911) contends that finance is an enabler for economic progress, as the services offered by the financial sector facilitate the efficient allocation of money and resources to their most valuable utilization while minimizing the risk of loss resulting from adverse selection, moral hazard, or transaction costs. In contrast, Robinson (1952) asserts that finance tends to follow where enterprise leads. This literature posits that economies with favorable growth prospects establish financial markets to facilitate the provision of cash required to sustain their promising growth chances. In such instances, the economy takes the lead, and finance subsequently follows.

There is a lack of study that considers the influence of global elements, such as international trade policies, exchange rate changes, and cross-border capital flows, on the relationship between innovation and MP. In an interconnected society, these

concerns may have significant consequences for the financing and development of innovation. Exchange rate variations may impact the expenses associated with imported research inputs, while international trade rules can either impede or facilitate the spread of breakthrough technology.

H0: Expansionary monetary policy positively influences R&D and technological innovation investment.

H1: Increased financial credit market development leads to greater technological innovation.

H3: Global factors such as trade and exchange rate moderate the innovation among residents and non-residents.

H4: Increases in wealth and GDP increase innovation among residents and non-residents.

H5: Depreciation of national currency leads to more foreign investment.

The wealth impact theory states that a relaxed MP will modify the allocation of individuals' wealth or boost the overall monetary worth of wealth in nominal terms. Consequently, this boosts consumption and overall demand, thereby promoting business investment (Li & Tan, 2019).

1.6. Layout of the Study

The thesis organizes the subsequent section as follows: Chapter two gives a detailed explanation of the theoretical and empirical framework. It also includes a literature review to analyze and evaluate any gaps that may exist in the current research. Chapter three offers a thorough examination of the data source, methodology, and the process of developing variables. Chapter four provides a detailed analysis of the estimation procedure and provides a summary of the obtained findings. Chapter five presents a succinct overview of the findings and conclusion.

CHAPTER II

A BRIEF REVIEW OF THE THEORETICAL AND EMPIRICAL LITERATURE REVIEW

2.1. Introduction

A comprehensive theoretical and empirical body of research has thoroughly examined the interplay between financial development, fiscal policy, and economic growth. The interplay between monetary policy and innovation has lately attracted considerable interest as policymakers and scholars aim to comprehend how monetary measures affect innovation dynamics and, subsequently, economic growth dynamics. Monetary policy, including central banks' operations to control the money supply and interest rates, is crucial in influencing the financial landscape for creative activity. The core of this relationship is the transmission mechanism by which alterations in monetary policy variables, such as interest rates, credit market conditions, and liquidity, influence innovation-related activities, including investment in research and development (R&D), entrepreneurship, and technological adoption. Although the literature exploring the connections between monetary policy and innovation has expanded significantly, the exact nature and extent of these impacts continue to be debated and investigated empirically. This literature review seeks to integrate and critically assess current research on the intricate relationship between monetary policy tools and innovation results, elucidating the processes, channels, and consequences of monetary policy in promoting innovation-driven economic development.

2.1.1. Channels through which Monetary Policy Affects Innovation

Research indicates that accommodative monetary policy, characterized by easy credit conditions, can enhance access to financing for innovative enterprises, particularly

small and medium-sized enterprises (SMEs), which often face constraints in accessing capital (Brown et al., 2018). Conversely, reducing the supply of funds or raising their cost restricts access to innovation and, consequently, decreases innovative activity (Popov ©amp; Van Horen 2013). If the MP transmission idea applies, the measures taken by the central bank to control the money supply and credit may affect firms' investment-financing decisions. This, in turn, can have a substantial influence on the entire operation of the economy (Lanfang, Yue, & Jing, 2022). The correlation between government subsidies and firms' R&D expenditure indicates that monetary policy influences this connection through credit limits and signal transmission (Wang and Yang 2022).

A lower interest rate encourages investment in productivity enhancement. These factors enhance the present value of future cash flows associated with improved productivity. This analysis indicates a second strategic factor. The theory of optimal order financing posits that changes in MP will have a direct impact on the external financing conditions for businesses (Yuhan & Ysang, 2023). Adopting a flexible MP will increase banks' inclinedness and ability to take on risks, whereas adopting a tighter MP will decrease the banking sector's willingness and capacity to undertake dangers. Amidst the ongoing changes and adjustments, sometimes referred to as the "new normal," the amount of money that companies spend in research and development (R&D) depends on the financial support they get from the government. These subsidies influence where the funds for corporate R&D come from and how successful they are. Furthermore, business research and development (R&D) spending closely correlates with monetary policy fluctuations throughout this period (Jiyou & Lei, 2023). The new normal in government financial support shapes the RD spending by companies. These subsidies thus affect both where business RD spending comes from and how successful it has been, as well as how RD spending by businesses has moved in response to fluctuations in monetary policy across this period (Jiyou & Lei, 2023).

Monetary policy therefore influences the relationship between corporate R&D and government subsidies, not only by restricting credit savailability through elevated interest rates and reserve requirements but also by disseminating signals. However, the absence of government subsidies definitely means that firms will have to rely more on credit and other means. Given a tight monetary policy, financial institutions will reduce their propensity and amount of lending. This, in turn, will lead to an increase in

fundraising costs, with businesses becoming less willing to undertake risky and uncertain R&D that is characterized by high upfront spending and probabilistic payoffs. Monetary policy settings that promote macroeconomic stability, like price stability (inflation targeting) and full employment, can set the context for innovation by reducing uncertainty and boosting investor confidence. Research shows that innovation investment and entrepreneurship thrive in countries with stable macroeconomic conditions because credible and transparent monetary policy regimes reduce uncertainty. Particularly, central banks' commitment to maintaining low and stable inflation fosters innovation-led growth by offering firms a stable macroeconomic environment for long-term planning and investment. (Mishkin, 2016).

Financial institutions with a restrictive monetary policy would decrease their willingness as well as the amount of lending, increasing the cost of buying money. The economy, in turn, would see a decline in corporate willingness to pursue high-risk and uncertain RD with unknown returns (Yukti, Smita, and Shveta, 2021). Changes in monetary policy, particularly unconventional measures such as QE or forward guidance, may impact firms' expectations about future economic and policy conditions, which may lead to a change in innovation investment patterns. Research suggests that policy uncertainty, arising from shifts in monetary policy regimes or geopolitical events, can influence firms' willingness to undertake risky innovation projects and their allocation of resources to innovation activities (Bloom et al., 2012). Clarifying monetary policy objectives and communication strategies can help reduce uncertainty and provide firms with greater confidence to invest in innovation (Woodford, 2012).

2.2. Theoritical Literature Review

The central banks use a range of tools to implement MP, which has a substantial influence on the economic process by enhancing the functioning of financial markets. Monetary policy significantly influences the conditions for innovation. Recent discussions that help to understand the operation of monetary policy channels can reveal valuable insights as to how changes in interest rates, liquidity, and credit conditions can affect firms' capacity to perform R&D and innovation. How important is monetary policy in terms of promoting innovation? That’s the debate. It concerns the specific routes through which monetary policy influences the economy, as well as how these channels alter the promotion of innovation.

- **Monetary Policy Transmission Mechanisms**

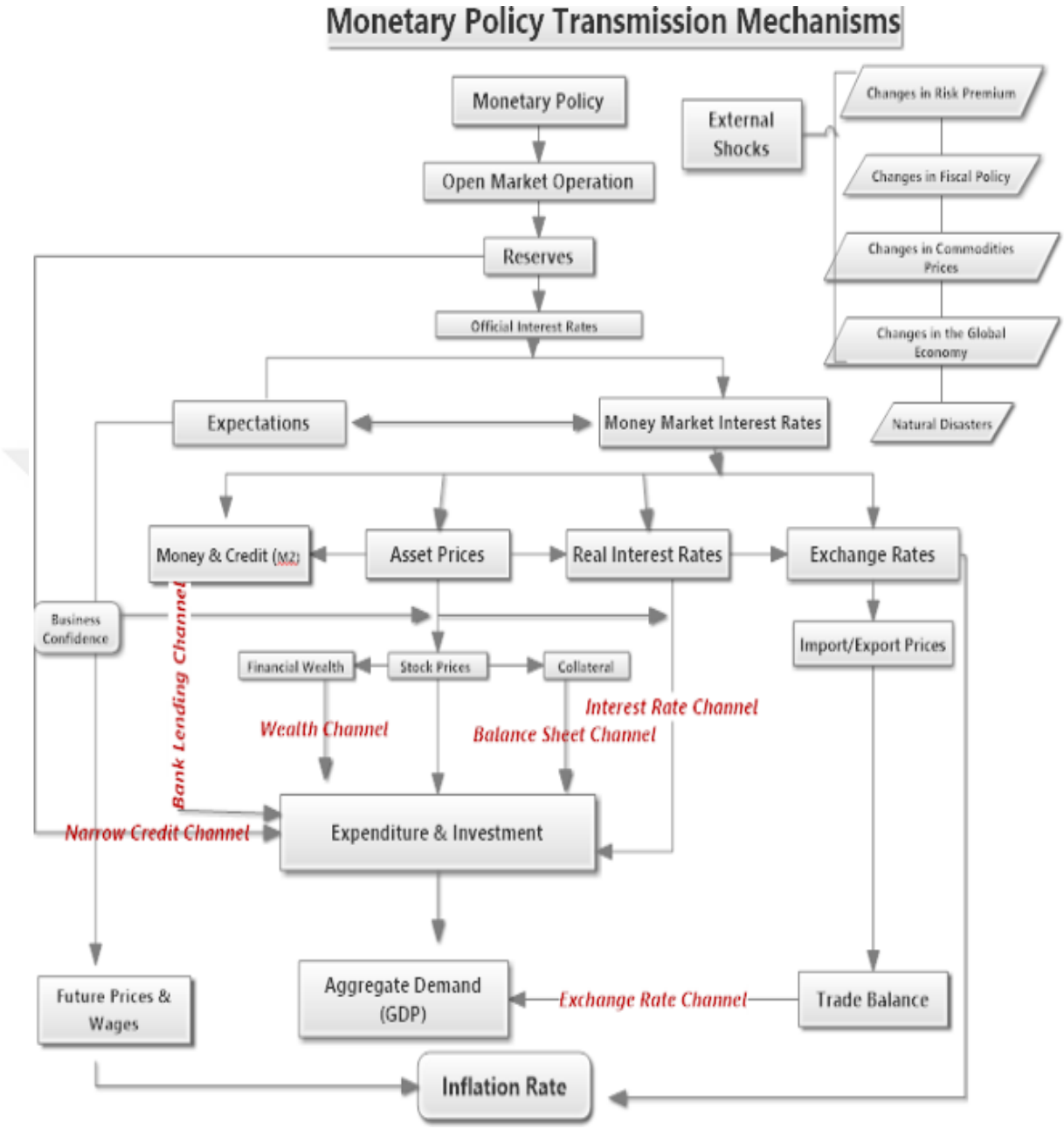

Figure 2.1. Monetary Policy Transmission Mechanism

Source: Chukwu et al (2009)

- **Channels of Monetary Policy Transmission Mechanism**

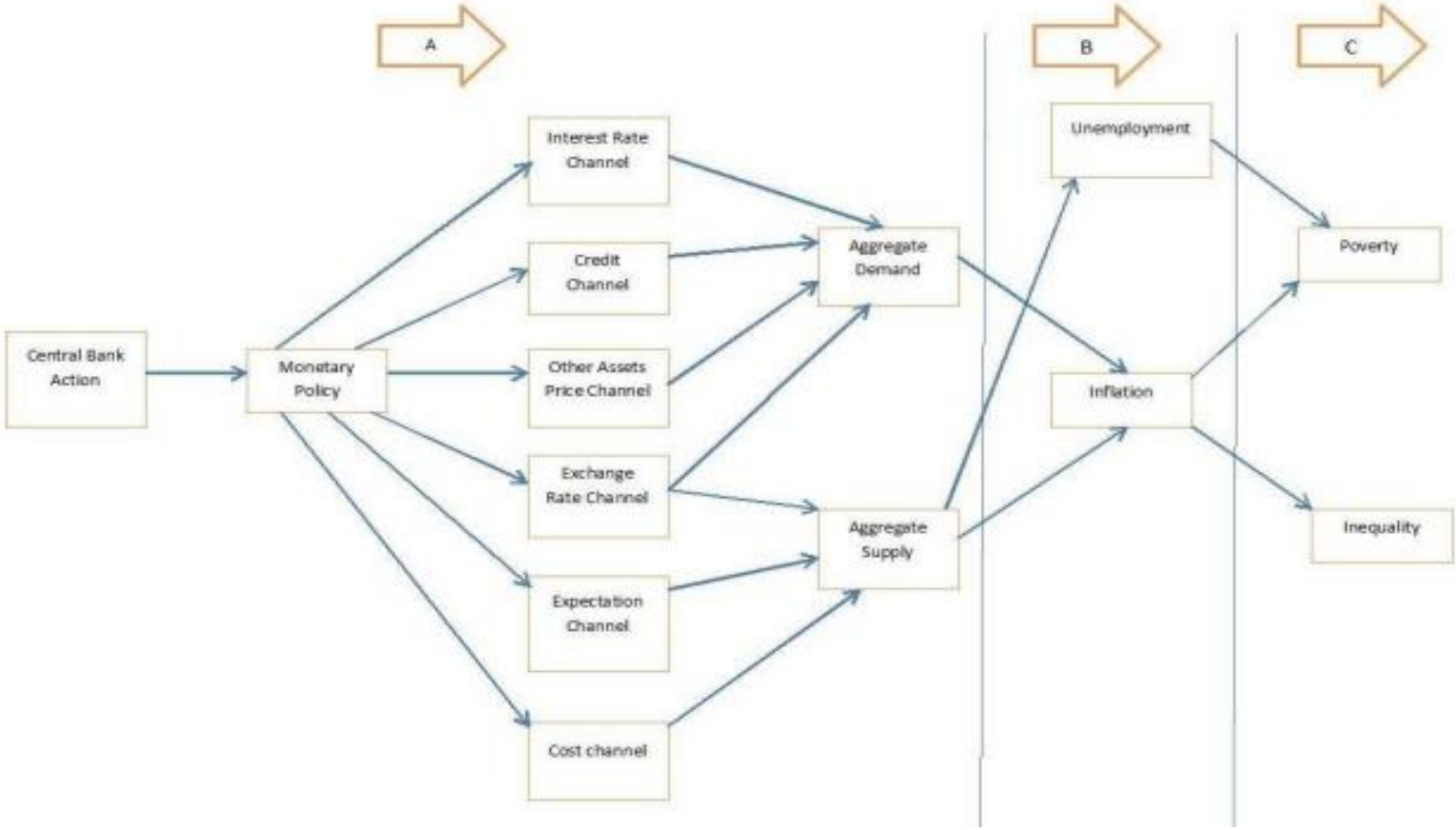

Figure 2.2. The Channel of MTM

Source: Mishkin (1995,1996 and

Innovation activity may be seen as a significant way in which MP impacts the supply side of the economy, perhaps resulting in lasting effects on economic growth.

2.2.1. Interest Rate Channel

IR is a key channel for the MPTM as it affects the economy. Benmelech and Bergman (2012) demonstrate that firms with better access to credit, facilitated by lower interest rates, engage more in innovative activities as they can finance the upfront costs of R&D. Similarly, Aghion et al. (2019) highlight that monetary policy, through its influence on interest rates, shapes firms' innovation incentives by altering the cost of external financing. When IR is low, the opportunity cost of investing in R&D decreases, leading to an increase in innovative output. Casual observations suggest that shifts in the interest environment over the past decade have had noticeable effects on innovation funding, such as VC investment. During the years of low interest rates, venture funding was abundant, and startups expanded rapidly. As interest rates increased substantially since early 2022, venture funding fell sharply, and startups struggled to survive (National Venture Capital Association, 2023).

$$M \downarrow \rightarrow i \uparrow \text{VC} \rightarrow \downarrow \rightarrow I\text{NV} \downarrow \rightarrow Y \downarrow \uparrow \qquad \textbf{(2.1)}$$

The IR channel comprises the subsequent factors. The variable "M" in the equation indicates that a restricted MP can result in higher IR, which in turn increases the capital cost and has a negative impact on venture capital investment spending. These decisions to increase IR result in a decrease in corporate stock value. Additionally, it will lead to a reduction in overall demand and a reduction in yield. Hence, the interest rate channel has an equal impact on both consumer spending and investment choices pertaining to startups. The interest rate channel emphasizes that changes in IR can influence overall economic activity through monetary policy. In this scenario, changes in the short-term nominal interest rate impact the medium- and long-term interest rates through the mechanism that balances demand and supply in the money market. Changes in interest rates have a direct impact on capital expenditures, which in turn influence investment and consumer expenditure as part of aggregate demand (Mishkin, 1995).

2.2.2. The Credit Constraint Channel

Monetary policy could affect the investment and financing decisions of firms, particularly about their research and development (R&D) spending and the creation of new products. This influence occurs via the money and credit channels and ultimately has a significant effect on the overall functioning of the economy (Lanfang, Yue, & Jing, 2022). The credit constraint channel of MP captures any way in which contractionary monetary policy (or weaker economic conditions) makes it harder for a firm to finance innovative activity. Credit constraints significantly hinder innovation, particularly for SMEs and startups, which often rely heavily on external financing for their innovative activities (Nanda and Nicholas, 2014). Contractionary monetary policy shocks can exacerbate these constraints, increasing the likelihood that firms report a lack of funds as a significant barrier to undertaking innovation. This is critical because the availability of funds directly impacts the ability to invest in long-term, risky R&D projects. This can reflect tighter aggregate credit supply and lower asset prices, which reduce borrowers' collateral value and therefore borrowing capacity, the 'financial accelerator channel' (Bernanke, Gertler, and Gilchrist 1999). SMEs are more likely to be credit- or cash-constrained than larger firms. Foreign-owned firms may be better able to access credit from overseas markets or from their overseas parent (Dahlquist and Robertsson 2001). Thus, they may be more sensitive to the global, not the domestic, cost of capital. As such, they may be less affected by domestic credit conditions. Levine (1997) and Beck et al. (2000) emphasize that FD significantly contributes to EG by improving capital allocation and supporting entrepreneurial activities. Chukwu et al. (2009) and Mengesha & Holmes (2013) highlight the significance of the credit channel in transmitting MP effects, particularly in developing economies where financial markets are less developed.

2.2.3. Exchange Rate Channel

The literature on the ER channel mechanism underscores its pivotal role in shaping economic activities and innovation. Studies highlight that exchange rate fluctuations influence the cost of R&D, international competitiveness, and investment flows, thereby affecting innovation outcomes like patents and venture capital investments. Gertler and Karadi (2015) demonstrate how monetary policy-induced exchange rate

movements impact firms' export performance and R&D spending. Alfaro et al. (2004) and Eichengreen et al. (2007) discuss the attractiveness of venture capital investments in response to currency depreciation or appreciation, noting that foreign investors are particularly sensitive to these fluctuations. Collectively, the literature suggests a complex interplay between monetary policy, exchange rates, and innovation dynamics, emphasizing the importance of a stable exchange rate environment for fostering long-term technological advancement and economic growth. When domestic RIR, domestic currency becomes less seductive relative to the foreign currencies. The value of a dollar asset relative to other currencies makes domestic goods cheaper than foreign goods, which increases the foreign investment.

$$i\downarrow \rightarrow \text{E} \uparrow \rightarrow \text{PANR} \uparrow \rightarrow \text{Y} \uparrow \rightarrow \text{NX} \uparrow \qquad \textbf{(2.2)}$$

2.2.4. Wealth Effect

The wealth effect posits that a permissive MP would alter the distribution of individuals' wealth or augment the overall value of nominal wealth, so stimulating consumption and aggregate demand, and consequently encouraging corporate investment (Li & Tan, 2019). The current monetary balance effect demonstrates that loose monetary policy will influence the amount of money people hold via the pricing mechanism, with the aim of stimulating public expenditure and hence fostering private investment.

Simultaneously, in accordance with demand theory, MP can influence the investment in innovation by companies through the demand effect (Huang, 2019). By increasing the money supply and decreasing market IR, loose MP reduces the opportunity cost of capital, changing the net present value of R&D projects from negative to positive and encouraging firms to invest more in R&D. This is particularly significant given the long cycles and high uncertainty of innovation investments, which are sensitive to real interest rate changes. Additionally, optimistic future capital expectations due to lose monetary policy may drive firms to increase R&D investment to enhance product competitiveness.

2.2.5. Demand Channel

According to the demand theory, MP can influence firms' innovation investment via the demand channel (Hoaung, 2020). Aggregate demand in the economy is an important transmission channel for monetary policy. A contractionary monetary policy shock shrinks aggregate demand, which can reduce profitability and incentives for innovation. The collapse in aggregate demand will result in lower potential future profits for firms, which will reduce their incentive to innovate. Investments may also drop as financial conditions tighten and risk appetite declines.

Firms have incentives to innovate because it encourages higher expected profits in the future (for example, Aghion and Howitt, 2008). Hence, a decline in aggregate demand should result in a lower probability that firms engage in innovative production. On the other hand, an expansionary monetary policy should increase aggregate demand, increase the profitability of new product development, and boost incentives to innovate. Diminished demand might cause slower innovation, which could have long-lasting negative effects on economic growth and technological change. Benigno & Fornaro (2017).

After an expansion-driven increase, RD spending and patenting intensity respond more strongly to the contractionary monetary policy. Also, this sensitivity looks a lot like it does in industries that are known to be demand-sensitive or have high asset beta (Comin Gertler, 2006), which means that demand changes more quickly in response to changes in the economy. For large publicly listed firms, with a high debt-to-assets ratio across most industries and a substantial competitive advantage secured via patented technologies, it is unlikely that monetary policy shocks have significant effects on their access to financial resources; thus, their slowdown in innovation is likely to be due to a demand effect. This implies that both small and large firms, as well as all industries, are subject to the demand effect of monetary policy. (Shleifer, 1986; Fatas, 2000).

2.2.6. Cost and Supply Channel

High interest rates reduce firms' borrowing capacity and boost production costs, prompting them to prioritize short-term profitability over long-term innovation . Since rising inflation diminishes the motivation to invest in new ideas and raises the actual interest rate used to evaluate projects, firms would stop innovating and submit fewer patents. This atmosphere for innovation and rising prices due to manufacturing costs enhance the risk of nominal and real inflation, making research and development expenditures even less advantageous. Because of these production-cost ramifications, the inflation philosophy examined in this article leads to frontloaded inflation and lower long-run growth. Rising capital and interest rates enhance manufacturing costs, which theoretically and empirically diminish innovation, patents, and R&D. According to studies, higher working capital expenses influence pricing, output, and economic activity, which impacts RD and innovation. High costs delay corporate innovation and decrease internal research unit engagement in proprietary innovations. This should encourage companies to collaborate with complementary technology providers to share RD expenses and profits, as well as improve breakthrough discoveries. Some companies use cost-cutting technology to combat growing production expenses. Thus, high interest rates and inflation foster collaborative innovation, including patenting, but make generic, incremental advancements impossible. In conclusion, dual-stage innovation-generated stacking products may improve patents despite a poor innovation and RD environment.

According to Bajaj (2021), a strict MP would reduce market liquidity, limit the amount of capital available for allocation, increase the costs and complexity of funding innovation-related investments, and hinder the ability to secure external funding. Furthermore, in addition to the detrimental effect on the time value of non-monetary assets and mortgages mentioned above, a strict MP would also impair the ability for innovative firms to get mortgages, further limiting their access to external funding.

Theoretically, higher interest rates and capital costs increase firms' marginal production costs, leading to higher product prices and lower profitability (Hulsewig et al., 2009). This economic pressure often results in a reduction in available capital for investment in R&D, which is essential for innovation. Empirical evidence supports

this relationship; Barth and Ramey (2001) observed that many companies in the US raised prices following monetary shocks, suggesting that increased financial strain from higher costs can deter investment in innovation.

When bank loan provisions are interrupted, the bank lending channel emerges when there is an interruption of bank loan provisions, resulting in extra expenses for companies that heavily rely on bank credit inflows. Specifically, economic cycles may influence SMEs' relatively elevated and more susceptible external finance costs (Bernanke et al., 1999). In general, this mechanism results in a reduction in profitability and the inclination to innovate (Huber, 2018). The decrease in public investment in research and development (R&D) may lead to a decline in financial circumstances, prompting the government to consolidate its budget, thereby impacting spending on innovation. The main part of quantitative easing that moves money around is how large-scale asset purchases affect the medium- to long-term IR and how lower yields on corporate bonds lower the cost of borrowing money. Bank lending may also have a positive impact, as there will be more funds available for credit financing. Furthermore, the presence of trust and firmly established expectations may reduce uncertainty, thereby mitigating credit risk and, more broadly, reducing the external finance premium (Stefanski, 2022). Grimm et al. (2022) conducted research demonstrating that direct acquisition of corporate bonds can promote innovation expenditure by transferring capital to more inventive companies. Furthermore, more advantageous financial circumstances may facilitate the stimulation of public investment in innovation, thereby alleviating the burden of interest payments.

2.3. Empirical Literature Review

The next part of this thesis moves beyond the theoretical perspectives to empirical literature, which deals with real-world data and studies that explain the consequences and practical implications of monetary policy and innovation. This is done through analyzing different empirical findings, aiming to fill the gap between theory and practice by giving an in-depth understanding of it.

2.3.1. Empirical Literature Review: Country-wise Analysis

Ma et al, (2023) illustrates the impact of MP on innovation using local projection regressions and a structural vector autoregression (SVAR) model. Analyzing US datasets from 1969 to 2007 to assess the impulse response to monetary policy shocks. The analysis encompasses metrics such as R&D spending, venture capital (VC) investment, and patenting in important technologies, using data on real GDP, unemployment, investment in physical and intellectual property products, and VC investment. In the findings, a 100-basis point tightening monetary policy shock implies that there are significant declines of 1 to 3 percent in R&D expenditures or spending, 25 percent decline in VC investments and patents in critical technologies, highlighting the influence of MP on demand, financial conditions, and innovation activities. activities. They argue that R&D and patenting are more reactive to changes in monetary policy in cycles sectors meaning that monetary policy affecting through demand conditions has an impact on this level of innovation – demand channel. The study also finds evidence showing decrease in venture capital funding after contractionary monetary policies which may also reduce the amount of funds available for innovative activities – financial channel.

Moran and Queralto (2018) individually analyze the effect of monetary policy rules that incorporate new uncertainty shocks on innovation and investment. Furthermore, by highlighting the significance of Monetary Policy (MP) in fostering investment and innovation, they enhance the rate and deflationary impact of these distortions on Total Factor Productivity (TFP). Through the New Keynesian Model that considers Total Factor Productivity as endogenous, their study lay down these impacts in the fThey formalize an economy that consists of overlapping generations with market-determined interest rates, employs an explicit production technology with diminishing returns to capital and labor, and features one good and multiple identical firms competing through a price and Calvo pricing regime. pricing regime. They continue the discussion by analyzing how a zero lower bound (ZLB) could constrain monetary policy, explaining the rise in monetary policy in the US in 2016 and the impact of this gradual tightening of monetary policy on total factor productivity (TFP). Their data shows that imposing a ZLB constraint as a stopping rule for the zero lower bound in the US from 2009 to 2015 resulted in a drop of up to 2 percent inFurthermore, they

argue that the approval in 2016 of a more restrictive monetary policy, which ceased upon reaching 50 and was followed by a 75 bp stabilization rule, not only prevented the US economy from losing confidence, but also had long-term welfare benefits that increased TFP and GDP by more than 1 percent. Finally, we employed the VAR model to investigate the dynamic relationship between R&D and TFP, demonstrating that an increase in R&D leads to a long-term increase in TFP. increase in R&D.

Moreover, fiscal policy as well as monetary policy are significant in promoting corporate innovation (e.g., small firms). Since a loose policy can make people more motivated to come up with new ideas, Lingxing et al. (2023) look at how much a loose policy affects new product development (NPD) measures of innovation. They do this by using firm-level data from 13,078 A-share listed companies from 2006 to 2022. Lingxing et al. (2023) use panel regression and VAR models to investigate the relationship between loose MP and NPD R&D innovation. They measure this relationship using short-term interest rates and fiscal subsidies, which all indicate the promotion effect of loose MP. Firms are more willing to devote resources to innovations. In a cost-effective manner, loose monetary policy provides firms with much-needed financing and capital subsidies. As a result, it encourages corporate innovation enterprises to invest more in NPD and technological innovation. The introduction of fiscal subsidies further strengthens the effect of MP on innovation. Fiscal premiums supplement short-term interest rates for MP, improve the market mechanism for lending decisions, and lower the cost of financing. The paper also addresses the heterogeneity of MP's impact on industries and firm traits. MP has a greater impact on technological innovation. Fiscal subsidies positively enhance MP's effect. The study contributes to understanding the mechanisms by which MP affects innovation, addressing the knowledge gap in previous innovation literature related to China. Theoretically and practically, policymakers can better use fiscal and monetary policy instruments to facilitate innovation-led economic growth.

However, empirical evidence shows that there is a positive correlation between corporate innovation and MPS based on a data set of 3082 Chinese listed firms in 2007-19. We applied several variables, including R&D inputs and patent applications, to benchmark the measure of innovation. This study used the fixed-effect estimation model with robust standard errors to control potential endogeneity. The research

primarily reveals the positive spillover effect of MPS on innovation initiatives in competitive sectors or those with better financial strength and market growth activities. The paper measures the remaining part of the term after deducting the Taylor rule as an MPS variable, which is more effective in periods of economic boom. Firms regard central bank policy actions as an important force in their innovation, and future studies should analyze how various types of monetary policies would affect innovation in different sectors or regions. These findings have strong policy implications for improving China's innovation-driven economic growth.

Wang and Yang (2022) conducted an analysis on the impact of monetary policy and product market competition on the R&D investment of Chinese listed enterprises between 2013 and 2018. Using the fixed effects model, the authors examine the role of MP measures, including lending interest rates, open money injection from the monetary sector, and return on equity as a proxy for competitive pressure in the product market. Even after controlling for a series of industry and firm characteristics, the results suggest that loose monetary policy boosts R&D investment, while tight policy hurts it. Higher product market competition has a stronger effect on the positive interaction between accommodative policy (loose money) and R&D investment—a conditional effect. The authors find support for their findings using new patent data and lagged controls. The authors support their findings. 2019 by Wuhan et al. (2015).

Based on the long-run co-integration test of Johansen and short-run by VECM to analyze, it has been shown that there is a negative relationship in the long run while interest rate affects investment positively in the short term. The results show that the margin of interest rate policy has a considerable impact on investment and is meaningful to economic growth in Jiangsu Province.

Countries with good governance and financial structure also provide subsidies for the promotion of innovation. The study by Zhang et al. (2022) delves into the effects of government innovation subsidies on business R&D investment, how these subsidies work, and how expansionary monetary policy affects these effects. The authors create government innovation subsidy and non-innovation subsidy indicators using a text search method and data on China A-share listed companies from 2007 to 2017. Employing a fixed-effect model with robust standard errors, the study assesses

variables such as R&D expenses, firm size, age, leverage, and macroeconomic indicators like GDP growth Their research shows that government innovation subsidies encourage R&D spending by businesses by lowering the cost of debt financing and increasing the use of internal funding sources. Government innovation subsidies do encourage corporations to engage in research and development, but loose monetary policy mitigates this impact. In order to encourage innovation in the business world, the study suggests macroeconomic policy modifications. As a signal to outside investors, the authors argue that the government could utilise innovation subsidies to lower the costs of corporate debt financing and raise the bar for screening companies in order to pick the best ones. The beneficial impact of innovation subsidies on research and development investment funded by internal business funds should also be considered by the government.

(Majeed et al., 2024) examines the impact of MP and economic conditions on innovation in Australia, a small open economy that tends to import innovation. The authors use firmlevel data and aggregate measures to analyze the effects. They find that restrictive MP reduces aggregate R&D spending, and lower R&D spending reduces future productivity. However, the firm-level results show heterogeneous responses, with small firms decreasing innovation while large firms increase it in response to MP shocks. This appears to reflect differences in exposure to the demand and credit constraint channels through which monetary policy affects innovation. The study also reveals that the transmission of US MP has an impact on the creativity of Australian companies. In general, the findings indicate that both monetary policy and economic conditions have significant impacts on productivity in the medium term. However, these effects are more intricate than what has been previously recorded.

To investigate how financialization affects regional technology innovation and is linked to the monetary policy relationship (Cai, 2019), a study investigates the impact of financialization on technological innovation through analyzing provincial panel data from 2008 to 2016 in China by spatial econometric models. It will also use the financialization indices, innovation investment, infrastructure, fiscal autonomy, and marketization as key variables. The findings suggest that, in general terms, financialization tends to have a negative impact on technological innovation anyhow, but it is further worsened by loose monetary policy. The spatial analysis of the

economy indicates serious regional inequalities in consequences, with the most adverse effects traced to eastern Chinese provinces. The researchers argue that policymakers must tackle the over-financialization stifling floral innovation and make sure their monetary policy is enhanced rather than undermined.

Monetary policy has a crucial role in attracting foreign investments due to its low cost of financing and the depreciation of the local currency, which increases profitability for foreign investors. Chen (2018) paper provides a survey of the literature on the longrun effects of MP on innovation and foreign direct investment (FDI). Using a blend of trend analysis, error correction models and GMM the study explores R&D expenditure data along with patent filings, FDI inflows and few macroeconomic variables including interest rates & inflation. The results show that supportive monetary policies have a significant impact on innovation activities and FDI inflow in Turkey, which implies further economic growth. But the research also shows that inconclusive or too tight monetary policies can crush entrepreneurial spirits and repel FDI. Enthusiasts should work to cultivate monetary policies that protect a healthy economic climate for innovation and reinvestment.

The Raza Kazam study utilizes annual data from 1977 to 2019 to investigate the impact of MP on consumption and investment in Pakistan. The analysis focuses on variables such as interest rate, consumer price index, real effective exchange rate, and macroeconomic indicators including private consumption, public consumption, and gross fixed capital formation. Their study analyzes the immediate and prolonged relationships using the Johansen and Julius co-integration tests, VECM, and VAR models. Increases in IR lead to a decrease in investment because higher borrowing costs discourage the allocation of resources toward consumption. Fluctuations in the consumer price index have a beneficial impact on investment because higher prices lead to increased company revenue. The positive correlation between the ER and investment underscores the importance of a stable currency in promoting economic growth. This comprehensive analysis assists policymakers in effectively managing monetary policies to achieve demand stabilization and stimulate investment in Pakistan.

2.3.2. Green Innovation

Nevertheless, there is research examining the influence of MP on green innovation. Their results will be detailed below. Green innovation, which is essential for addressing climate change, is also influenced by monetary policy. Due to the scarcity of research on this topic, a comprehensive exploration will be conducted.

Yin et al. (2022) used a panel data analysis to look at the effects of expansionary MP actions on green innovation. The study covered 133 countries, both developed and developing, from 1960 to 2018 and used a panel fixed effect model. They employed green patents as dependent variables, while broad money and reserve money served as independent variables. Their research generally found that these measures, whether analyzed in a static or dynamic model, significantly improve the performance of green innovation. Reduced central bank autonomy and inadequate property rights protection in developing countries may impede the seamless transmission of monetary policy to green innovation activity. Furthermore, the strict environmental regulations enhance the positive impact of the expansionary MP on green innovation. However, for this positive moderating effect to be effective, it is crucial to have excellent national governance quality, which includes better control over corruption, higher government efficiency, and a comprehensive legal system. As a result, we present a few policy recommendations. Loose MP measures have a clear and beneficial effect on green innovation performance, which supports our main premise as stated in the introduction.

For economic and development to occur, it is essential to increase both the MS and certain characteristics of central banks. Spyromitros (2023) investigates the impact of LMP on green innovation in 109 countries between 2010 and 2018. Strategies greatly improve the effectiveness of eco-friendly innovation. An increase in GDP per capita, government spending, and bureaucratic efficiency all help to promote green economic activities. The central bank's independence and decreased IR in emerging countries have a significant impact on green innovation. Expansionary monetary policy, central bank openness, and energy-related variables all contribute to the promotion of sustainable economic growth in affluent countries and facilitate the development of environmentally friendly innovations in Latin American, East Asian, and Pacific

nations. The effect of expansionary MP on green innovation is greater in countries with high institutional quality, industrial concentration, energy intensity, and central bank characteristics conducive to innovation, while inflation and trade openness dampen the connection between monetary expansion and green growth (Spyromitros, 2023).

Beyond MP, non-traditional MP is a core aspect of technological innovation of other nations, as the developed economies have a much stronger overall influence than other economies do. In this study, Tufail et al. (2024) use the dynamic autoregressive distributed lag (DARDL) model and the kernel-based regularized least squares (KRLS) model to perform a comprehensive analysis on the complementary relationship between the traditional and non-traditional MP in the United States (US), European Union (EU), and China, as well as the dynamic impact on green investment in the world. The results show that the traditional MP in the US does not usually promote international green investment. The conventional MP shows a negative effect on green investment in the short run and a positive effect in the long run in the EU. The conventional MP in China positively stimulates international green investment in the long run. Quantitative easing and other unorthodox approaches to loosen monetary policy have a negative immediate effect in the US and a positive long-term effect both in China and the EU. The paper also finds that financial development promotes green investment in the short run and has a negative effect in the long run in China but shows no clear impact in the US and in the EU. In summary, it is easier to promote green investment in the long run, but not in the short run in these advanced economies. The global monetary policy is not conducive to the world entering the sustainable economy in the short run and needs more support.

The study comes with several limitations. For instance, the sample size is relatively small, and more investigations can focus on a longer time period to improve the reliability of results. Often, economic policy uncertainty will mitigate the stimulating effect of loose MP policy motivated by green growth. Sometimes, analyis is to see and analyzed if and how economic policy uncertainty (EPU) influences green innovation in 31 provinces within China for the period of 2000-2017. In the panel fixed effects model, we found that there exists an inverse relationship between EPU and green innovations. The effect is stronger, however, in well-marketed and more open-to-trade

provinces. It seems that EPU will allow regional economies to better exploit the positive spillover effect of innovation induced by EPU. Therefore, to sustain innovation in the context of economic policy uncertainties, the policymakers should promote the level of marketization and further liberalize the nation to the rest of the world. (Peng et al., 2022).

Here Samoilikova, Vasylieva, and Lieonov (2022) employed the GMM to estimate the effect of government expenditures on R&D and education on the green economic performance index (GEE) in 68 countries from 2008 to 2018. The paper shows the results with panel data that informs both RDD and regional differences. While both R&D and education positively affect the green economy, the achieved advantages in the technology and composition dimensions are dependent on each country's level of per capita GDP. Bangladesh is a good example of how the GEE decreased over time. The paper acknowledges that the only option for governments is to increase public investment in research and development and education, further improving market institutions, as well as regional cooperation and integration in order to sway green economic growth in a sustainable direction. forthcoming researh.

Jian and Zhengjie (2024) examine the influence of several variables on carbon emissions that are associated with consumption in China. The influential variables to be concerned with are some of monetary policy uncertainty, a natural resources-based economy, financing technology, fiscal federalism design, and trade. The study employs quarterly data range from 2005q1 to 2021q4 yearly, while bootstrap autoregressive distributed lag (ARDL) techniques are used. The mentioned variables have a significant effect on the reduction of carbon consumption emissions (CCE), but fiscal decentralization has the major trace. However, factors such as monetary policy uncertainty, the use of financial technology (fintech), and dependence on natural resources lead to a rise in CCE. We observe that imports increase the current account balance, while exports decrease it. The error correction term indicates a quarterly adjustment of 61.0% towards equilibrium. There is a bidirectional causation relationship among most factors, with the exception of fintech, policy uncertainty, and CCE. This indicates that policy changes might have major environmental impacts. The study emphasizes the intricate interaction between these elements and the need for

more research on their enduring and industry-specific effects to effectively guide sustainable development initiatives.

2.3.3. Global Studies

Carvelli et al. (2024) study the effects of ECB MP on private and government innovation dynamics in the European zone from 2001 to 2021 using a structural VAR framework. The findings show that MP contractions negatively impact private R&D with a 2-4 quarter lag, while the negative effect on government R&D fades after 5 years. Unconventional monetary policy UMP affects public R&D faster than private, but the positive impacts dissipate more quickly. The findings show that the relationship between private and government innovation and the projected returns to research and development (R&D), which depend on aggregate demand, influence the transmission of the ECB's policy. Future research should account for cross-country heterogeneity in innovation responses to a common monetary policy. The results show how important the credit channel, the balance sheet channel, and the bank-lending channel are for connecting monetary policy to innovation. They also show how different types of money have different effects on innovation over different time periods.

We use empirical evidence to gain a scientific understanding of the impact of MP tools and indicators on the dynamics of funding innovation. This study used data from Ukraine and 12 post-soviet countries from 2010 to 2019, utilizing available statistics from various organizations, e.g., “IMF and WDI,” for all indicators. The study employed regression analysis, specifically using a linear regression model with panel-corrected standard errors, as well as correlation analysis using Pearson and Spearman coefficients. We used these methods to validate the influence of monetary instruments and indicators on funding innovation promotion and to quantify the resulting effect. To stimulate innovation, the government can reduce discount and real interest rates, increase the amount of "broad money" held in general reserves, and grow the liquid reserves held against bank assets. Calculations indicate that Ukraine and 12 other countries had a contrasting effect on all monetary instruments and indices, with the exception of the discount rate. The monetary instruments in Ukraine are not adequately performing their regulatory function in stimulating innovation growth (Anastasiia Samoilikova, 2022).

Yang et al. (2024) conducted a study on the relationship between MP The text discusses the pace at which total factor productivity (TFPG) and innovation efficiency (IE) are increasing. They analyzed both time series and cross-sectional data mixture data from 30 nations spanning the years 1983 to 2018, using the bias-corrected fixed-effect dynamic (BCFE) model. Implementing a strict MP has demonstrated a detrimental effect on the growth rate of total factor productivity (TFPG) and innovation efficiency (IE). That's exactly what we found when we used different sub-samples and other independent variables based on empirical analysis and specific models. Countries with relatively more efficient governments, FD, and environmental laws greatly reduce or completely get rid of the chance that a stricter MP will hurt general factor productivity, innovation efficiency, and overall development. The authors illustrated how a stricter MP will have a negative effect not only on 'overall factor productivity' but also on its most significant stimulator, namely, 'innovation efficiency'.

Fazal Zeehan (2019) Monetary policy and socio-economic indicators Debate rages over the role of MP in development economics. In developing countries, MP appears to influence the value of wealth assets and, as a result, the distribution of income, with the wealthiest individuals reaping the largest benefits. To investigate the effect of MP on socio-economic indicators such as income inequality, poverty, and inflation, we have used cross-sectional data from 61 developing countries for the year 2005 and 57 for the year 2015. We collected the data from WDI 2017 and IFS. The analysis has been performed using structural equation modeling (SEM) because we are interested in the multifaceted effect of MP and the existence of multiple causal paths. We used R for data analysis throughout this project, and we tested the causal relationships between the MP structure indicators and socio-economic indicators using AMOS 24 (structural equation modeling). Our research showed that expansionary monetary policy reduces poverty and unemployment in the short run, but the long-term inflationary pressures caused by a policy of credit expansion undermine economic stability and growth by lowering spending and investment, leading to a recession.

In their study, Samoilikova, Vasylieva, and Lieonov (2022) evaluated the effect of government expenditure on research and development (R&D) and education through the green economic performance index (GEE) in 68 countries using the GMM. The

study is based on panel data from 2008 to 2018. The research shows that the increase in both research and development (R&D) and education has a positive influence on the green economy. However, the specific advantages in terms of technology and composition vary across countries with different per capita GDP levels. The research also found that countries such as Bangladesh and Pakistan have seen a reduction in their GEE over time. The paper suggests that governments should increase public investment in research and development and education, improve the quality of market institutions, and promote regional cooperation and integration to support sustainable green economic growth. forthcoming research.

2.3.4. Financial Development and Innovation

Financial development plays a crucial role in the process of EG and effectively transmits MP (Durusu-Ciftci, 2017). Excessive financialization has a negative impact on economic growth because there is an inconsistent correlation between FD and economic expansion. Once a country exceeds the FD threshold, the influence of financial development on economic growth tends to diminish and can even become detrimental. This discovery also applies to the correlation between financial development and inventive endeavors. The interplay between these two components distinguishes two recognized strands in the finance-innovation literature. Morales (2003; Bravo-Biosca, 2007) suggests that FD has a favorable influence on innovation. The main idea behind this argument is that having well-established financial markets would improve information availability, which would in turn reduce the risk associated with uncertain innovative initiatives. This would then encourage investors to provide funding for young and innovative companies. Furthermore, the financial sector's advancement has a detrimental effect on innovation. This is because increased financial growth leads to an expansion of market power, which in turn discourages innovation (Brown et al., 2009). The lack of consistency in the data regarding the relationship between finance and innovation raises a highly discussed question: does an abundance of finance have a negative or positive impact on innovation, and is this relationship linear or nonlinear?

Facilitating the growth of financial markets would stimulate innovation by providing new, innovative companies with convenient access to the required financial resources.

The dynamic innovation of young enterprises would drive innovation. Encouraging the expansion of financial markets can foster innovation by providing new and inventive enterprises with accessible financial resources. Young startups' dynamic innovation would force established companies to innovate, creating a creative destruction environment that encourages innovative activities. Established companies encourage innovation, creating an environment of creative destruction that promotes innovative activity. Trinugroho, Law, & Chang (2021) measured the relationship between foreign direct investment (FD) and innovation using domestic credit, private sector credit, and patents granted per labor, respectively. However, they found a nonlinear relationship using data from 68 developed and developing countries between 1995 and 2018. This relationship may be enhanced by market institutions such as property rights, rule of law, government effectiveness, and corruption control. The research demonstrates that the expansion of a nation's credit and stock markets, up to a certain threshold, positively influences its innovation. The research uses regression discontinuity design and dynamic system panel to address endogeneity and nonlinearity challenges. Ganda (2024) analyzed the connections between technical innovation and financial development. Ganda (2024) employed the GMM panel VAR methodology to examine the relationship between technological innovation, such as patent applications and R&D expenditure, and financial development in the BRICS states from 1990 to 2020. The analysis indicates a robust inverse correlation between technical innovation and economic development. This study discovered a significant negative connection between FD and technical innovation. The impulse response function shows a dramatic growth in the proportion of each variable that other factors can account for over time, spanning from short to long terms. Using firm-level data from 18 developing countries, Aristiza Bal-Ramirez et al. (2011) demonstrate that FD has a negative impact on the likelihood of a firm to innovate.

In a study on institutions and innovation, Nemliogglu and Mallickk (2020b) investigated whether multilateral lending is more successful in gathering capital in innovative nations. The study examines the impact of World Bank/IMF funding on capital stock in 175 countries between 1970 and 2017, focusing on FDI and debt. According to the study, long-term FDI has a positive impact on domestic capital stock, but non-G7 countries, despite higher innovation, cannot benefit from increased FDI due to institutional quality differences. Multilateral lending helps a borrowing nation

only if it has more intellectual capital or uses the funds for finance. Unlike short-term IMF loans, World Bank funding focuses on long-term development objectives and stimulates productive capital. Multilateral funding benefits countries with strong institutions and innovation, resulting in an increased capital stock upon implementation of the Trade-Related Aspects of Intellectual Property Rights agreement. Aristizabal-Ramiirez et al. (2017), however, show that weak institutional quality limits the effect of FD on INN.

Conversely, certain research has found a direct correlation between innovation and financial development. In their 2021 study, Baloch et al. examine a set of OECD countries from 1991 to 2017. To analyze the data, they use the Pooled Mean Group Autoregressive Distributed Lag (PMG/ARDL) estimator and discover that financial growth positively influences green innovation. The study relies on data from the "World Growth Indicators (WDI) Financial Development Index." Similarly, Pardhan et al. (2016), utilizing a VAR model based on data from 13 countries in the Eurozone, argue that 'innovation has a positive effect on FD measures for stock capitalization and for the credit market' and, again, significantly impacts RD investment. The findings imply that the well-developed financial systems play a role in fostering higher investment in activities related to innovative activities that drive economic growth.

According to Mtar's (2020) study, there is no relationship between FD and INN. However, they assert that human capital functions as a moderator to moderate the impact of the FD-INN relationship, suggesting that policymakers should prioritize the provision of entrepreneurial-related educational training and the enhancement of people's professional qualifications. Khan et al. (2020) also assert that human capital moderates the relationship between FD and INN in China. Similarly, based on the GMM estimation, Zhu et al. [2020] use a panel of 50 countries from 1990 to 2016, in which they propose that FD has no relation with INN.

In their study, Xiao and Zhao (2012) analyze data from 46 nations between 2002 and 2005 at the business level. They find that stock market development has a greater impact than banking sector development when it comes to explaining innovation. The results, however, demonstrate that the impact of banking sector development is more noticeable in promoting innovation in countries where government ownership of banks

is smaller. Nevertheless, Tee et al. [2012] present divergent findings in a study examining East Asian economies. The authors utilize the random effects estimate technique to demonstrate that banking sector development has a favorable impact on innovation, whereas stock market development has a negligible impact. Liu et al. (2021) performed research from 2003 to 2015, examining the relationship between rural financial growth and agricultural technical innovation in 31 Chinese regions. The research demonstrates that the growth of financial services in rural areas has a favorable impact on the advancement of agricultural technology innovation by improving the size and effectiveness of financial operations. The authors argue that financial size and financial efficiency are essential determinants of financial growth, especially in rural areas of China. The two criteria discussed here signify the extent of financial resource allocation for economic activities (financial scale) and the effectiveness of resource allocation within the financial system (financial efficiency).

Hsuan et al. (2012) investigate the connection among financial market development and technological innovation in 32 developed and emerging nations. To analyze this influence, they employ a fixed effects identification technique. The results indicate that industries that rely on external funding and those with a high degree of technological intensity demonstrate greater levels of innovation in nations with well-established equity markets. In contrast, well-developed loan markets tend to inhibit innovation in these industries. The study provides new perspectives on the distinct functions of stock and credit markets in promoting innovation, emphasizing the importance of financial market systems in driving economic growth and technological progress.

CHAPTER III

DATA, METHODOLOGY MODEL SPECIFICATION

This chapter consists of an explanation of the variables, a specification of the model, and the estimation techniques that will be used in the analysis of MP, FD, and innovation.

3.1. Data Description

Innovation has always been challenging to measure in literature. As pointed out by Duguet and Iung (2011), high citations of patents hold the highest value, followed by patent applications and grants. Zhong (2018) argued that acedemic studies usually measure research and development expenditure, an indicator of innovation, using several indicators such as R&D investment, the ratio of R&D investment to GDP, and the number of patent applications. The real rate of interest serves as a reliable indicator for monetary policy.

3.1.1. Measures of Innovation

According to Griliches, Z. (1990), the quantity of patent applications used as a dependable measure to evaluate a country's level of innovation. Technological innovation includes patent applications from both local and international organizations. Moreover, the data is thoroughly recorded in a methodical fashion in each nation, rendering it a very efficient and dependable measure of a nation's level of innovation (Wen et al., 2021).

3.1.2. Patents

The existing literature views patents as valuable in assessing technology innovation. They not only quantify the output of innovation, but they also reflect the efficiency

with which an organization utilizes its innovative inputs (Fang et al., 2014). According to Griliches (1990), a patent provides direct evidence of R&D and innovation activities. Therefore, patent data can serve as a reliable measure of innovation performance. Acaj et al. (2002) and Jalles (2010) have contended that patents serve as a metric for gauging the results of innovation, whereas patent applications quantify the intermediate products within the innovation process. As a result, we can study the dynamics of the innovation system using easily accessible patent databases. Thus, we can systematically document and readily access patent data, which serves as a reliable indicator of innovation.

3.1.3. Patent Application by Residents

The variable patent by resident reflects the innovation expenditure by the residents in their country. It serves as a measure of domestic innovation activities, economic conditions, and the potential of local inventors and enterprises to produce new technologies. The data pertaining to this variable is crucial for the country's domestic technical development and the conditions for local investment. The subject matter encompasses both small SMEs and small patents, namely those that pertain to local businesses, as well as the role of financiers in supporting them.

3.1.4. Patent Application by Non-residents

The variable reflects the number of patent applications filed by international or non-resident individuals in a specific country. The index assesses the economic conditions and attractiveness of a nation, as well as a location for foreign innovation and the extent of global reach and collaboration in technical developments. The investment by the international in other nations indicates a strong, well-developed financial market, law and order, and intellectual property protection inclusion into the global innovation network.

3.2. Independent Variable

3.2.1. Monetary Policy

A nation’s CB uses the tool of MP to control the supply of money and interest rate in an effort to achieve macroeconomic objectives such as inflation control, consumption management, economic growth, and liquidity maintenance. It is essential for stabilizing the economy and impacting economic activity. We evaluate monetary policy using a range of metrics. The central bank sets parameters for money supply, interest rates, and inflation rates. The CB establishes its PR, an interest rate, in reaction to the existing economic conditions. Variations in interest rates may influence the borrowing and investment decisions of corporations, particularly the funds they designate for research and development and innovation projects. Nonetheless, it does not accurately represent the true effect of this rate. We use the modified "real interest rate" adjusted for inflation to assess monetary policy and aggregate money supply. The term "real interest rate" denotes the prevailing rate at which borrowers may get funds, determined either by central banks or by market dynamics inside the financial system. Our study will examine the effects of interest rate changes on innovation levels across several economic contexts. We shall posit the premise that diminished interest rates foster innovation by lowering capital expenses and encouraging investment in long-term projects.

3.2.2. Financial Development

FD refers to the enhancement and expansion of a nation's financial institutions and markets, including banks, stock exchanges, credit systems, and financial services. The expansion of the financial market is essential for effective MP transmission. It refers to the improvement of efficiency and effectiveness within financial institutions, yielding benefits for people and promoting optimal resource allocation. We classify the impact of FD into credit market advancement and stock market expansion. We use DCPS (private sector credit) and domestic credit as indices to evaluate the evolution of the credit market. We quantify the proportion of domestic credit to the private sector (PSC) as a percentage of the total gross domestic product (GDP). The variable "DCPS" represents the amount of credit provided to private enterprises and individuals by

domestic financial institutions within a nation. This metric includes a range of credit options, such as loans, mortgages, and other types of finance. Ensuring the private sector has easy access to credit is essential for fostering innovation since it grants companies the essential capital to spend in inventive endeavors, such as creating new items, embracing cutting-edge technology, and expanding their operations.

3.2.3. Control Variables

The variables also impact the innovation, but not chosen as the main variables are real GDP per capita, GDP growth, and trade, as they are considered important factors influencing innovation. According to Wang (2013), GDP is considered a significant factor in determining innovation because a greater income level would enhance a country's capacity to initiate innovative activities. In addition, the openness of commerce promotes the diffusion of technology, thereby leading to positive effects on innovation inside the country where it is implemented. Dahlman (1994) emphasized that obtaining technology in developing nations can be achieved through access to foreign capital via foreign investment or imports of capital goods. According to Cheung and Lin (2004), it is suggested that inward (FDI) can have a positive impact on local innovation through various significant avenues.

Firstly, domestic enterprises might acquire knowledge about the products and technologies introduced by the foreign investor through the process of reverse engineering. Furthermore, labor turnover can facilitate the occurrence of spillovers. Domestic companies can acquire technology by employing skilled personnel from other countries. Furthermore, FDI has a demonstrative impact on local research and development (R&D) endeavors. Consequently, it has the potential to motivate and encourage local entrepreneurs to create a novel product based on foreign technology. International corporations have the capacity to provide education and the exchange of technological knowledge to local companies. This technique improves the ability of local suppliers to innovate. Cheung and Lin (2004) conducted an empirical analysis and found that FDI has a positive effect on the quantity of domestic patent applications in China. In general, trade openness and FDI are meant to drive innovation significantly, as they facilitate the importation of foreign technology that would then be adopted and used by local enterprises to contribute to future innovation.

3.2.4. The Descripition of the Variables

Table 3.1. Description of the Variables

The Descripition of the Variables	
Variables	**Description**
TI	Sum of patents by residents and non-residents
PAR	Patents filled by residents
PANR	Patents filled by non-residents
RII	The real interest rate
Broad Money	Total amount of money in circulation
FD	Domestic credit to private sector
Trade-Openness	The ratio of total export-import volume to GDP.
GDP	Growth in the GDP
GDP/PC	GDP per capita growth for local patents
ER	Exchange rate for non-residents and total innovation
FDI	Foreign Direct invest inflow and outflow

Source: World Development Indicators

The data table above explains the variables used in our study. The data is extracted from "World Development Indicators (WDI)" and consists of annual statistics. The study focuses on the BRICS countries and employs yearly data.

3.3. Model Specification and Methodology

This work employs an enhanced model derived from the analysis of extensive literature, methodology, and variables used in prior research. After doing extensive research and reviewing the techniques, the following strategies are employed:

The ARDL Model is a flexible econometric method that is commonly used to find the relationship between a dependent variable and one or more independent variables in both the short and long term. It does this by integrating time series variables of orders I(0) (stationary at levels) and I(1) (stationary at first difference). This method's primary

feature is its ability to incorporate lagged values into both the dependent and independent variables, thereby incorporating dynamic elements into the model. The steps are listed below.

The first step of the analysis entails the computation of descriptive statistics of the original dataset's, which show centeral tendencies like mean, median, and variance, such as standard deviation, followed by the presentation of the data in graphical format, such as a line chart.

Before proceeding to the main econometric technique, the Augmented Dickey-Fuller (ADF) test is conducted to check whether our time series is stationary. Stationarity is important because non-stationary data can result in a spurious regression, generally creating relationships between variables where there are none. The ADF tests whether the variable has a unit root (i.e., is non-stationary). If this is the case, we typically perform a difference test on the variable. The ADF test confirms whether the model runs on valid data, and it can accept a mixture of I(0) stationary and I(1) first-differenced variables but not higher-order differenced data.

After verifying stationarity, we apply the bounds test to determine if the dependent and independent variables exhibit cointegration over the long term. The F-statistic is the test's basis, and it compares its value with critical values to determine whether cointegration exists or not. From the step, it is evident that when there is cointegration, the variables move together over the long term, despite short-term fluctuations. This situation necessitates the continuation of modeling within the ARDL framework, as it enables us to model both short-term adjustments and long-term equilibriums. On the contrary, in the absence of cointegration, it would be inappropriate to model the long-term relationship between the dependent and independent variables.

The ARDL, therefore, seeks to estimate both the short-run and long-run relationship by including lagged values of the dependent variable and the independent variables. The dual focus helps capture the strengths of ARDL, which always provides insights about the current behavior (in the short run) and long-run equilibrium relationship over time. The lag length is critical because it corresponds to the correct level of temporal dependencies embedded in the data. This robustness comes from the fact that variables

could have different levels of integration in the ARDL model. Specifically, the ARDL adeptly manages time series data with varying integration orders, akin to the economic and financial time series encountered in real-world applications.

We can confirm cointegration if the variable values are positive and statistically significant. However, this observation enables us to transform the ARDL model into an Error Correction Model (ECM), indicating the speed of correction of deviations from long-run equilibrium. The error correction term (the term '1') determines the speed of adjustment by indicating how much of the disturbance from the previous period is rectified in the current period. The ECM is important because it depicts the dynamic adjustment process by indicating how the system rebalances when exposed to short-term shocks. It discerns the length of shocks and the stability of long-run equilibrium.

The stationarity of the dependent variable at I(0), for instance, means that the data series generating yt remains stable over time without having to difference it; the mean and the variance of the series remain the same. In these situations, a given model can directly introduce the variable without the need for differentiation or transformation. Finding all the independent and dependent variables in a given model at I(0) simplifies the situation significantly, eliminating the need for co-integration tests and the need to consider or estimate long-run equilibrium relationships between variables. By focusing on their lagged values, you can primarily concentrate on the short-run dynamics and one-period effects of these variables. Since such a condition implies stability over time, the variables reflecting I(0) stationary series are easier to predict and work with in the context of a time series model.

3.3.1. ARDL Model Framework

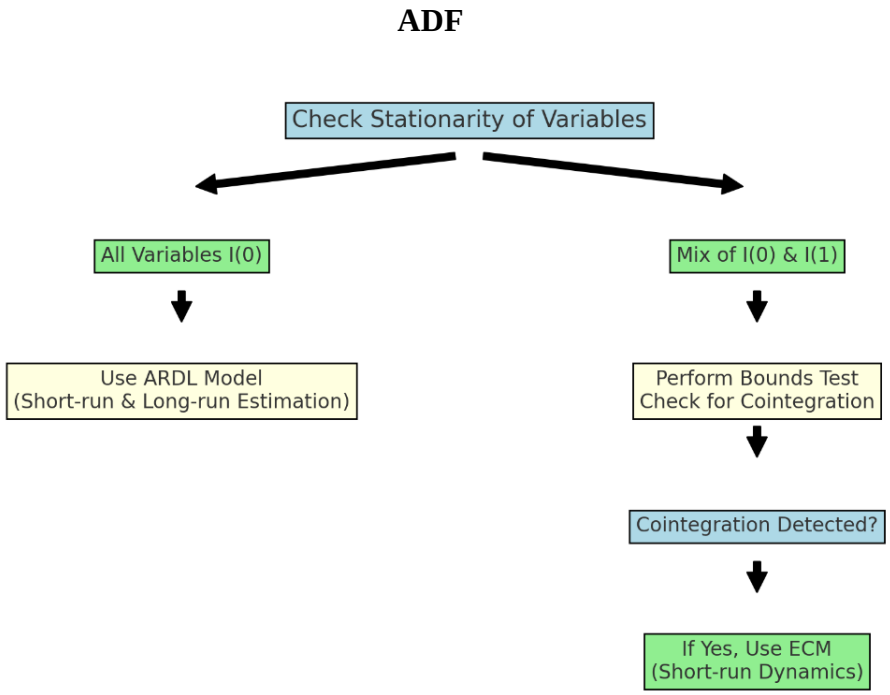

Figure 3.1. ARDL Model Framework

3.3.2. Conceptual Framework

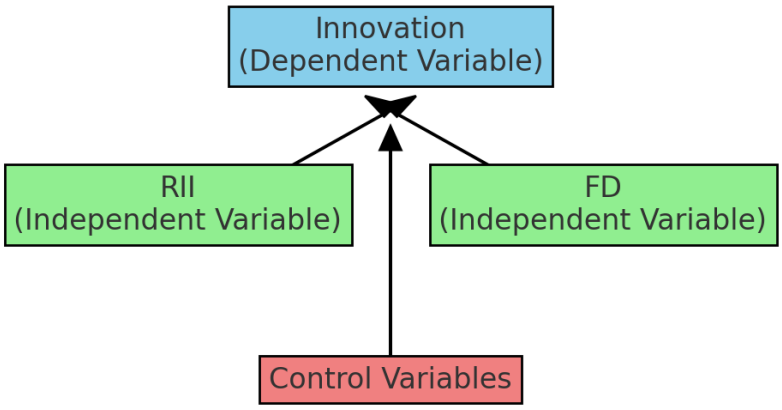

Figure 3.2. Conceptual Econometric Model

3.3.3. Econometric Models

General Model

$$\mathbf{Y_t} = \beta_0 + \beta_1 t + \sum_{i=1}^{P} \theta_i . Y_{t-i} + \sum_{i=0}^{p} \gamma_i . X_{t-i} \sum_{i=0}^{q} \phi_i . Z_{t-i} + \sum_{i=0}^{r} \delta_i . Z_{t-i} + \epsilon_t$$

(3.1)

Specific Model

$$\mathbf{INN_t} = \beta_0 + \beta_1 t + \sum_{j=0}^{P} \theta_i . INN_{t-j} + \sum_{j=0}^{p} \gamma_i . MPt_{t-j} \sum_{j=0}^{q} \phi_i . FD +$$

$$\sum_{j=0}^{r} \delta_i . Z_{t-j} + \epsilon_t \quad \textbf{(3.2)}$$

This is the general model where Yt represents the dependent variable (innovation) at time t and,$X\text{-}t{-}i.$ and,$Z\text{-}t{-}i.$ are the independent variables at time t-i and,$Z\text{-}t{-}i.$ represents the control variables and α represents the constant term including error term,$\epsilon\text{-}t.$

3.4. Unit Root Testing

The ADF test is often utilized to evaluate the stationarity of time series data. It pertains to analyzing the statistical properties of a variable to determine whether its statistical characteristics, such as mean, variance, and autocorrelation, stay stable over time. The ADF test estimated the following regression.
where:

$$\Delta \, yt = \alpha + \beta . t + \gamma Y_{t-i} \sum_{i=0}^{p} \gamma_i \, \Delta t_{t-i} + \epsilon \, t \qquad \textbf{(3.3)}$$

where Δ yt represents the first difference of the dependent variable α represents the constant term and β t is the trent term where t represents the trend term and γ is the lagged value of,$Y\text{-}t{-}i.$ and error term.

3.5. ARDL Model

There are three models as innovation is measured using three different innovation indicators. This model is applicable when the dependent variable is stationary at the level. By taking the difference, the ARDL model is used, which indicates the absence of a long-run link. Bound testing, level equations, and error correction models are unnecessary. Exclusively the ARDL model will be used.

$$\mathbf{PAR_t} = \beta_0 + \beta_1 t + \sum_{i=0}^{P} \theta_i . \mathrm{PAR}_{t-j} + \sum_{j=0}^{p} \gamma_i . \mathrm{MPt}_{t-j} \sum_{k=0}^{q} \phi_i . \mathrm{FD} + \sum_{j=0}^{r} \delta_i . Z_{t-j} + \epsilon_t \quad \textbf{(3.4)}$$

$$\mathbf{PANR_t} = \beta_0 + \beta_1 t + \sum_{i=0}^{P} \theta_i . PAR_{t-j} + \sum_{i=0}^{p} \gamma_i . MPt_{t-j} \sum_{j=0}^{q} \phi_i . FD_{t-j} + \sum_{k=0}^{r} \delta_i . Z_{t-j} + \epsilon_t \quad \textbf{(3.5)}$$

$$\boldsymbol{TI_t} = \beta_0 + \beta_1 t + \sum_{j=0}^{P} \theta_i . PAR_{t-i} + \sum_{j=0}^{p} \gamma_i . MPt_{t-i} \sum_{j=0}^{q} \phi_i . FD + \sum_{j=0}^{r} \delta_i . Z_{t-i} + \epsilon_t \quad (\mathbf{3.6})$$

If all the variables are stationary at level, this equation will be used. PAR, PANR and TI is the sum of patents applications by residents and non residents and $\beta_0 + \beta_1 t$ is the intercept and time trend respectively. Other variables MPt is the lagged value measured by interest rate and FD lagged value is also used and measured by "(DCPS)" Zt is the set of control variables. It may consist of FDIt, ERt TRADEt, GDPGt, GDPPCt and ϵ_t represent residual or error term that include variable that effect PAR but not included in the model.

3.6. ECM AND BOUND TEST

When the dependent variable exhibits stationarity at first difference and independent variables have mixed integration level, indicates the presence of co-integration, we reject the null hypothesis. We shall use these models if the dependent variable exhibits stationarity at first difference, and if any individual independent variable displays stationarity at first difference.

$$\Delta PAR_t = \beta_0 + \beta_1 t + \theta_1 X_{t-1} + \theta_2 Z_{t-1} + \theta_3 PAR_{t-1} + \sum_{i=1}^{P} \theta_i . \Delta PAR_{t-i} + \sum_{i=0}^{p} \gamma_j . \Delta MPt_{t-j} \sum_{j=0}^{q} \phi_i . \Delta FD + \sum_{j=0}^{r} \delta_i . \Delta Z_{t-j} + \epsilon_t \quad \textbf{(3.7)}$$

$$\Delta PANR_t = \beta_0 + \beta_1 t + \theta_1 X_{t-1} + \theta_2 Z_{t-1} + \theta_3 PAR_{t-1} + \sum_{i=1}^{P} \theta_i . \Delta PAR_{t-j} + \sum_{j=0}^{p} \gamma_i . \Delta MPt_{t-j} \sum_{j=0}^{q} \phi_i . \Delta FD + \sum_{j=0}^{r} \delta_i . \Delta Z_{t-j} + \epsilon_t \quad (\mathbf{3.8})$$

$$\Delta TI = \beta_0 + \beta_1 t + \theta_1 X_{t-1} + \theta_2 Z_{t-1} + \theta_3 PAR_{t-1} + \sum_{j=1}^{P} \theta_i . \Delta PAR_{t-j} + \sum_{j=0}^{p} \gamma_i . \Delta MPt_{t-i} \sum_{j=0}^{q} \phi_i . \Delta FD + \sum_{j=0}^{r} \delta_i . \Delta Z_{t-j} + \epsilon_t + \quad (\mathbf{3.9})$$

The model shown above is an Error Correction Model (ECM) that incorporates the short-run and long-run relationship between variables. This model elucidates the relationship between the dependent variable PARt, PANRt, TIt, and its own lagged values, as well as the lagged values of additional exogenous variables. It accurately compensates for departures from the long-term balance. ECM, or Error Correction Model, is a very successful approach in time series analysis, particularly when working with Cointegrated variables.

CHAPTER IV

RESULTS & DISCUSSION

This chapter presents the findings and conclusions of the empirical research conducted to investigate the relationship between monetary policy, FD, and innovation, along with a comparative analysis of the BRICS nations. The document commences with a comprehensive elucidation and outcomes of preliminary assessments, including the stationarity examination and ARDL test, subsequently presenting the principal discoveries of the used econometric model. The study's results, ideas, and consequences are clarified within the context of its objective.

4.1. Case of Brazil

4.1.1. Descriptive Analysis of Data

Table 4.1. Descriptives Analysis of Data I

Variable	Obs	Mean	Std. Dev.	Min	Max
PAR	42	3438.619	1179.427	1855	5480
PANR	42	12989.738	7605.605	4221	25925
TI	42	16428.357	8699.255	6268	30884
MP	42	52.634	20.096	15.011	77.617
FD	42	55.888	25.077	27.686	134.114
GDPG	42	2.324	3.386	-4.35	9.2
GDPPC	42	0.91	3.325	-6.453	6.663
TRADE	42	22.649	5.303	14.391	37.656
ER	42	1.624	1.501	0	5.394

Source: WDI

4.1.2. Graphical Analysis

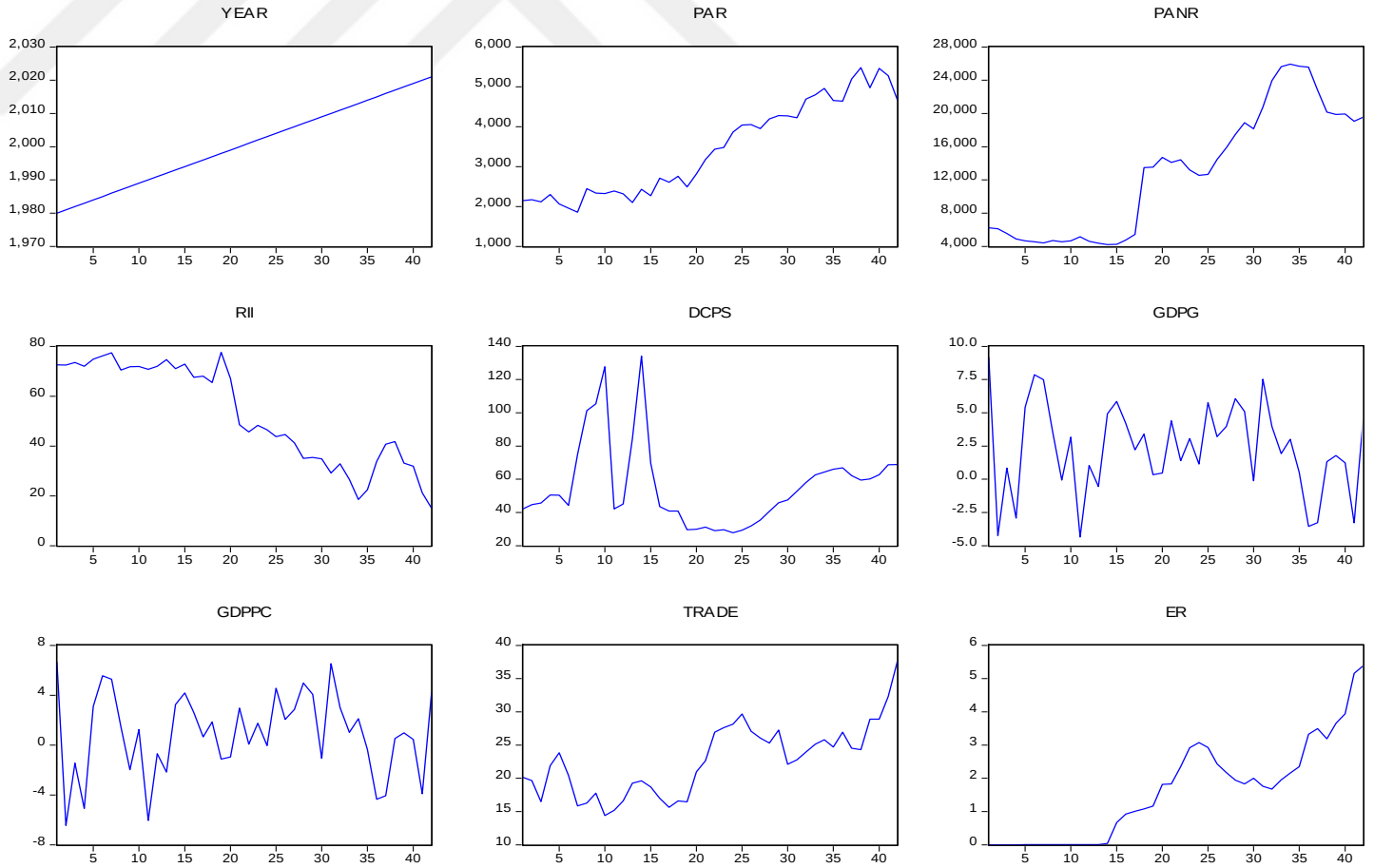

Figure 4.1. Brazil's Graphical Representation

4.1.3. Unit Root Test

The Augmented Dickey-Fuller (ADF) statistical measure used to assess the stationarity of time series data. This process is performed for all variables individually. The analysis includes both intercept and trend metrics. The findings are listened in the table below.

Table 4.2. Unit Root Test I

MP, FD, AND INNOVATION						
		At level		First Difference		Conclusion
Test	Variables	With Intercept	With Intercept and Trend	With Intercept	With Intercept and Trend	Conclusion
Augmented Dickey Fuller	PAR	-0.870	-2.989	-8.144***	-8.022***	I (1)
	PANR	-0.663	-1.842	-5.087***	-5.019***	I (1)
	TI	-0.628	-1.784	-5.527***	-5.452***	I (1)
	MP	0.302	-3.198*	-4.258***	-4.385***	I (1)
	FD	-2.269	-2.238	-6.112***	-6.031***	I (1)
	GDPG	-5.921***	-5.819			I (0)
	GDPPC	-5.909***	-5.973***			I (0)
	TRADE	-0.813	-2.383	-5.946***	-6.012***	I (1)
	ER	-2.753*	-1.986		-4.205***	I (1)

Note: ***, **, and * shows that the data is stationary and statistical significance at 1%, 5% and 10% significance level respectively.

Table 4.1.2. shows the integration order of the indicators used. Since the data has mixed stationary level i.e. I(0) and I(1), the bounds test for cointegration based on the ARDL approach is employed.

4.2. Case of China

4.2.1. Descriptive Analysis of Data

Table 4.3. Descriptives Analysis of Data II

Variable	Obs	Mean	Std. Dev.	Min	Max
PAR	37	343772.97	492592.4	3494	1426644
PANR	37	64824.081	55773.129	4051	159019
TI	37	408597.05	542571.77	8009	1585663
MP	37	1.768	3.261	-7.99	7.356
FD	37	114.524	30.5	66.192	182.868
GDPG	37	9.2	2.82	2.239	14.231
GDPPC	37	8.29	2.73	1.996	13.636
TRADE	37	39.62	11.773	19.881	64.479
ER	37	6.661	1.614	2.937	8.619

Source: WDI

4.2.2. Graphical Analysis

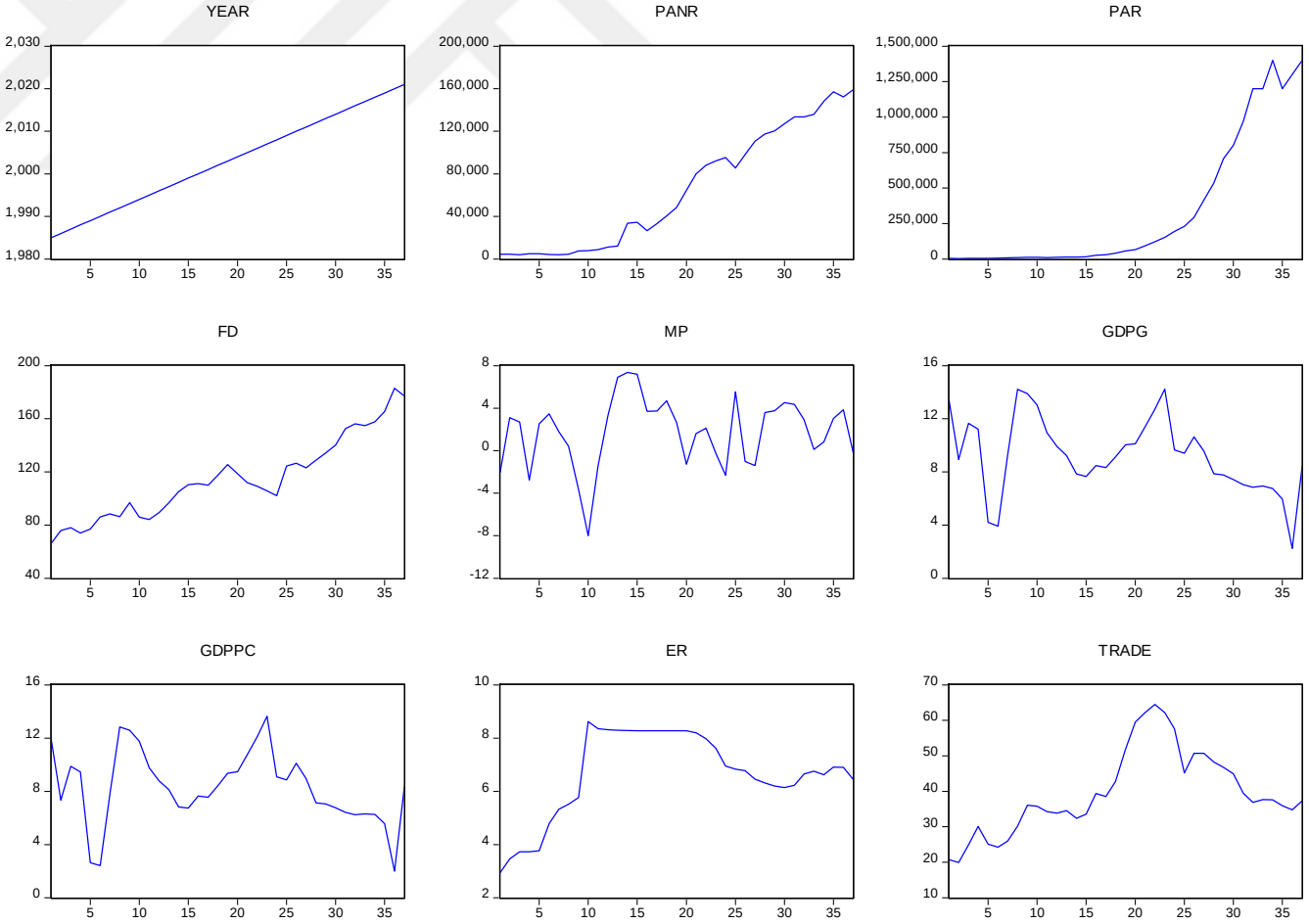

Figure 4.2. China's Graphical Representation

4.2.3. Unit Root Test

The Augmented Dickey-Fuller (ADF) statistical measure used to assess the stationarity of time series data. This process is performed for all variables individually. The analysis includes both intercept and trend metrics. The findings are shown in the table below.

Table 4.4. Unit Root Test II

	MP, FD, AND INNOVATION					
		At level		First Difference		Conclusion
Test	Variables	With Intercept	With Intercept and Trend	With Intercept	With Intercept and Trend	Conclusion
Augmented Dickey Fuller ADF	PAR	-0.597	-1.406	-4.505***	-4.355***	I (1)
	PANR	-0.912	-1.171	-5.678***	-5.686***	I (1)
	TI	0.013	0.013	-5.405***	-5.291***	I (1)
	MP	-3.852***	-3.798**			I (0)
	FD	-0.970	-0.970	-6.154***	-6.072***	I (1)
	GDPG	-3.617**	-3.747**			I (0)
	GDPPC	-3.285**	-3.433*			I (0)
	TRADE	-2.532	-1.795	-4.575***	-4.995***	I (1)
	ER	-3.396**	5.649***			I (0)

Note: ***, **, and * shows that the data is stationary and statistical significance at1%, 5% and 10% significance level respectively.

4.3. Case of India

4.3.1. Descriptive Analysis of Data

Table 4.5. Descriptive Analysis of Data III

Variable	Obs	Mean	Std. Dev.	Min	Max
PAR	42	5893.274	6525.127	982	26267
PANR	42	15132.512	13593.851	1817	35306
TL	42	21025.786	19502.972	2901	61573
MP	42	5.773	2.451	-1.984	9.191
FD	42	35.15	12.434	20.543	54.505
GDPG	42	5.898	2.672	-5.778	9.69
GDPPC	42	4.085	2.693	-6.673	8.819
TRADE	42	30.503	14.54	12.219	55.794
ER	42	38.955	20.226	7.863	74.1

Source: WDI

4.3.2. Graphical Analysis

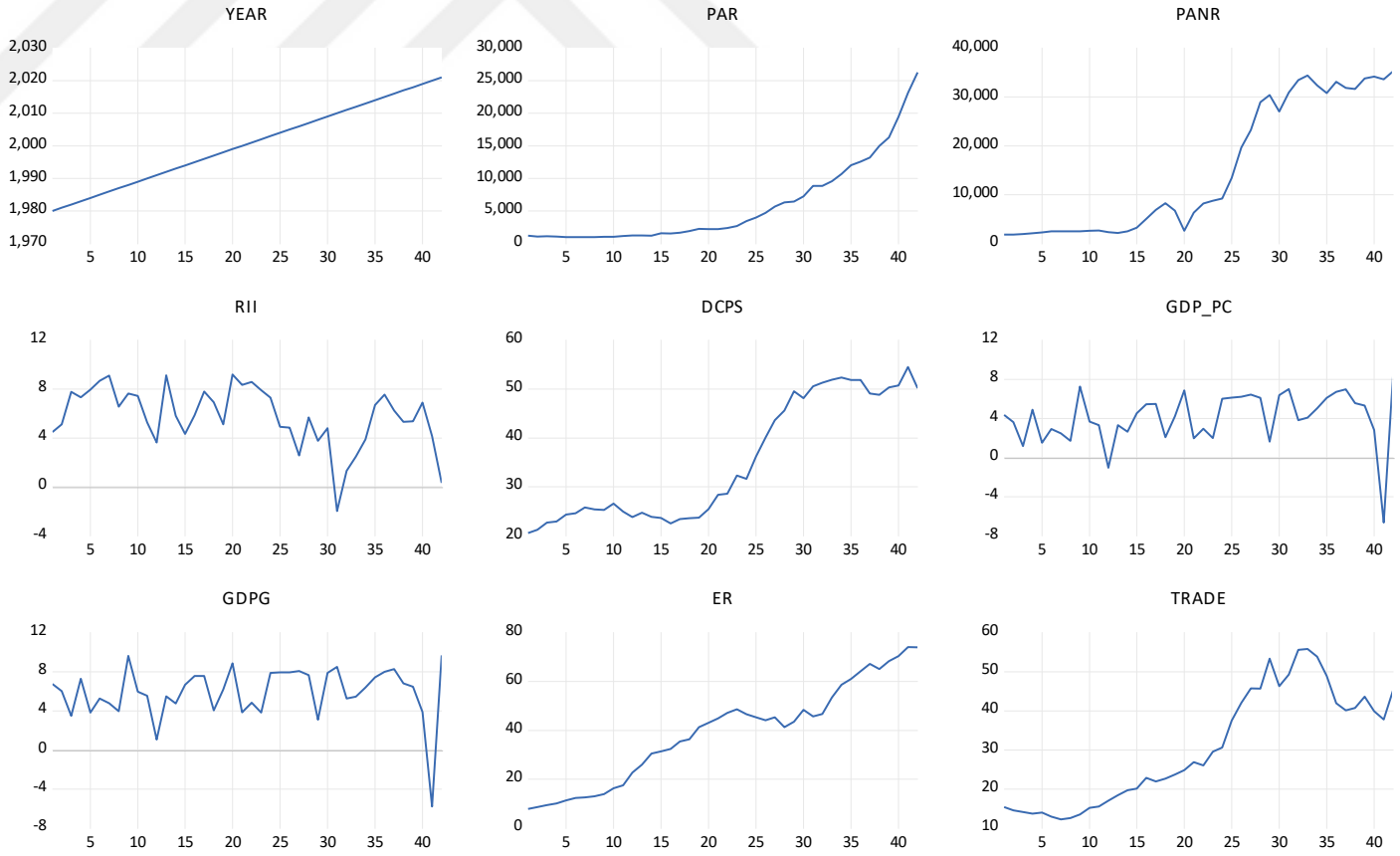

Figure 4.3. India's Graphical Representation

4.3.3. Unit Root Test

The Augmented Dickey-Fuller (ADF) statistical measure used to assess the stationarity of time series data. This process is performed for all variables individually. The analysis includes both intercept and trend metrics. The findings are shown in the table below.

Table 4.6. Unit Root Test III

MP, FD, AND INNOVATION						
		At level		First Difference		Conclusion
Test	Variables	With Intercept	With Intercept and Trend	With Intercept	With Intercept and Trend	Conclusion
Augmented Dickey Fuller ADF	PAR	11.269	-3.173	-5.167***	-6.194***	I (1)
	PANR	0.159	-2.061	-4.721***	-4.724***	I (1)
	TI	-0.181	-2.238	-5.663***	-5.591***	I (1)
	MP	-1.745	-2.542	-4.855***	-4.959***	I (1)
	FD	-0.777	-2.616	-7.372***	-7.235***	I (1)
	GDPG	-6.291***	-6.267***			I (0)
	GDPPC	-5.905***	-6.720***			I (0)
	TRADE	-0.605	-1.261	-5.152***	-5.096***	I (1)
	ER	-3.021**	-1.264		-4.198***	I (0)

Note: ***, **, and * shows that the data is stationary and statistical significance at 1%, 5% and 10% significance level respectively.

4.4. Case of Russia

4.4.1. Descripitive Analysis of Data

Table 4.7. Descriptive Analysis of Data IV

Variable	Obs	Mean	Std. Dev.	Min	Max
PANR	25	11854.8	2940.973	7205	16248
PAR	25	24432.4	3688.078	15106	29269
TI	25	36287.2	6030.505	23229	45517
MP	25	19.262	8.966	.048	38.616
FD	25	37.66	15.267	16.838	59.584
GDPG	25	12.225	4.328	1.2	19
GDPPC	25	3.277	4.512	-7.828	10.464
TRADE	25	52.852	6.585	45.967	69.393
ER	25	37.849	19.057	5.785	73.654

Source: WDI

4.4.2. Graphical Analysis

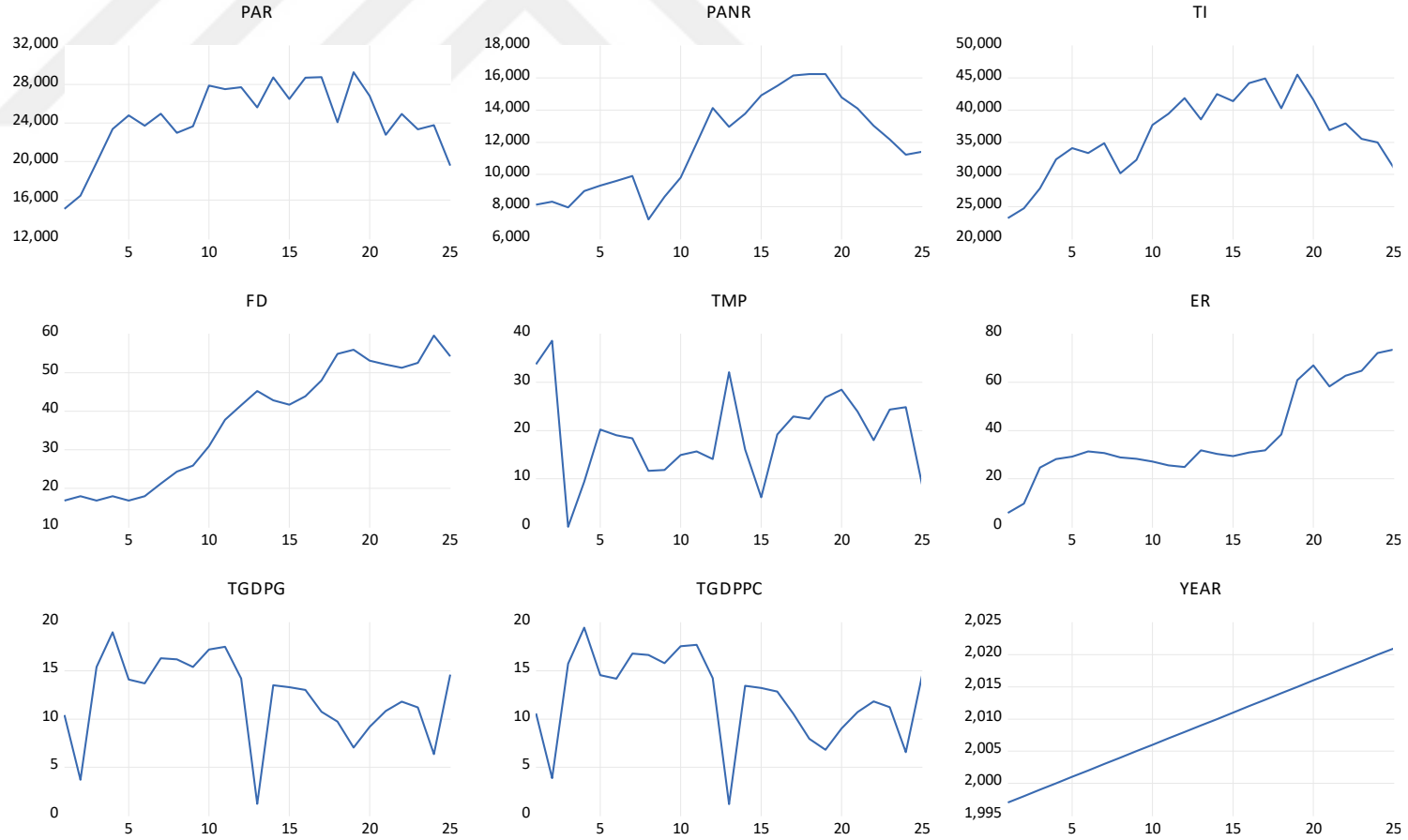

Figure 4.4. Russia's Graphical Representation

4.4.3. Unit Root Test

The Augmented Dickey-Fuller (ADF) statistical measure used to assess the stationarity of time series data. This process is performed for all variables individually. The analysis includes both intercept and trend metrics. The findings are shown in the table below.

Table 4.8. Unit Root Test IV

MP, FD, AND INNOVATION						
		At level		First Difference		Conclusion
Test	Variables	With Intercept	With Intercept and Trend	With Intercept	With Intercept and Trend	Conclusion
Augmented Dickey Fuller ADF	PAR	-2.874*	-1.570		-5.475***	I (1)
	PANR	-1.377	-0.528	-3.783***	-3.992**	I (1)
	TI	-2.250	-0.985	-5.059	-6.404***	I (1)
	MP	-4.167***	0.0141**			I (0)
	FD	-0.856	0.810	0.024**	-3.249*	I (1)
	GDPG	-3.650**	-3.921**			I (0)
	GDPPC	-3.422**	-3.744**			I (0)
	TRADE	-2.004	-0.983	-4.066	-7.541***	I (1)
	ER	-0.564	-1.535	-3.801***	-4.221**	I (1)

Note: ***, **, and * shows that the data is stationary and statistical significance at 1%, 5% and 10% significance level respectively.

4.5. Case of South Africa

4.5.1. Descripitive Analysis of Data

Table 4.9. Descriptive Analysis of Data V

Variable	Obs	Mean	Std.Dev	Min	Max
PAR	42	1595.45	1497.6	138	5134
PANR	42	5820.62	1184.05	2400	9156
TI	42	7416.07	1733.66	3140	10960
MP	42	4.084	3.986	-11.009	12.691
FD	42	100.699	26.555	50.085	142.422
GDPG	42	2.105	2.562	-5.963	6.621
GDPPC	42	0.359	2.788	-7.107	4.591
TRADE	42	48.393	7.465	34.321	65.975
ER	42	6.572	4.439	0.779	16.459

Source: WDI

4.5.2. Graphical Analysis

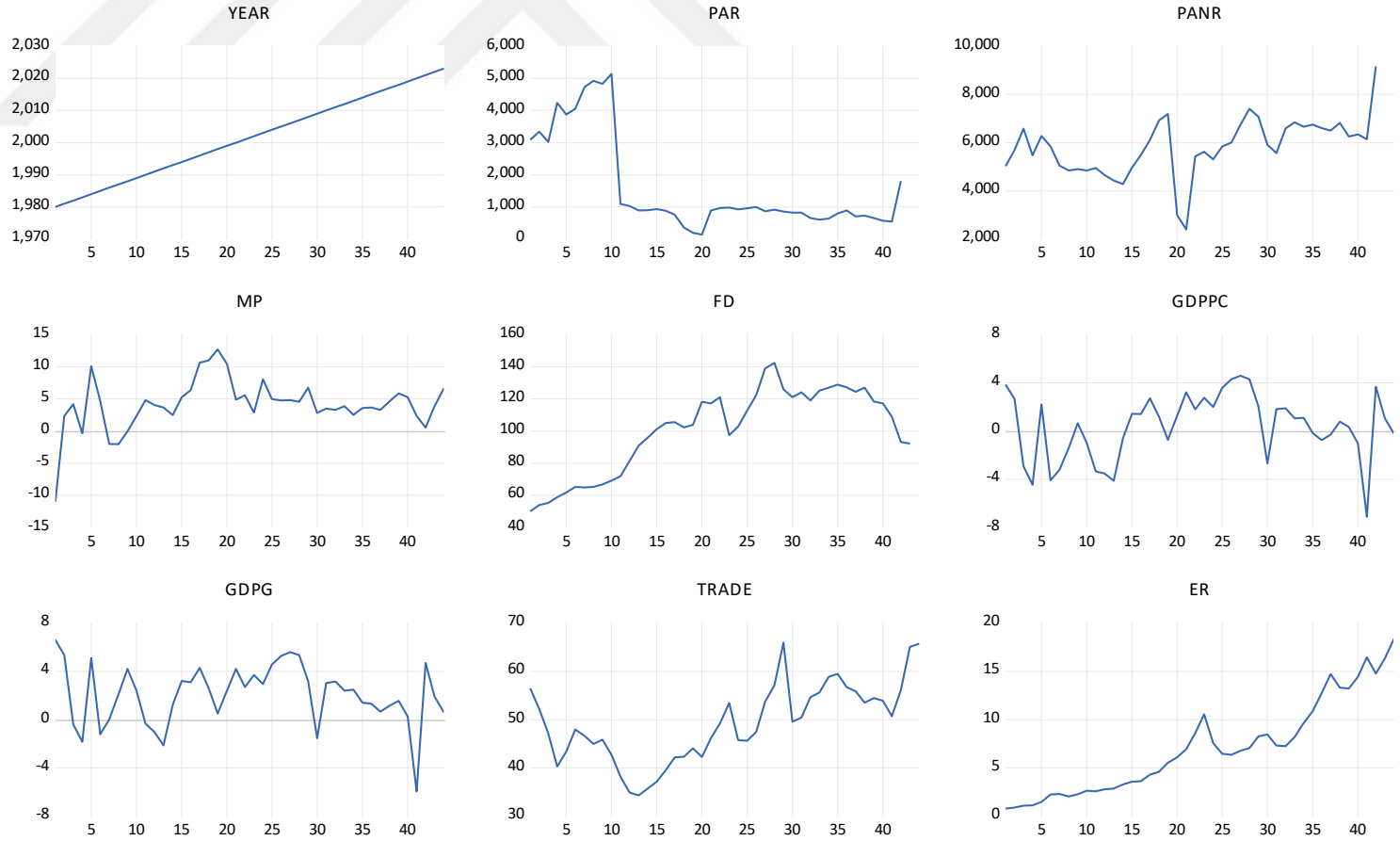

Figure 4.5. South Africa's Graphical Representation

4.5.3. Unit Root Test

The Augmented Dickey-Fuller (ADF) statistical measure is used to assess the stationarity of time series data. This process is performed for all variables individually. The analysis includes both intercept and trend metrics. The findings are shown in the table below.

Table 4.10. Unit Root Test V

		At level		First Difference		Conclusion
Test	**Variables**	**With Intercept**	**With Intercept and Trend**	**With Intercept**	**With Intercept and Trend**	**Conclusion**
Augmented Dickey Fuller ADF	PAR	-1.970	-1.795	-5.53***	-5.556***	I (1)
	PANR	-3.051**	-4.447**			I (0)
	TI	-2.565	-2.422	-5.94***	-5.989***	I (1)
	MP	-11.6***	-11.16***			I (0)
	FD	-2.516	-2.460	-7.525	-7.669	I (1)
	GDPG	-4.80***	-4.808***			I (0)
	GDPPC	-5.90***	-6.720***			I (0)
	TRADE	-1.358	-3.144	-5.90***	-6.019***	I (1)
	ER	-1.862	-3.140	-5.28***	-5.446***	I (1)

Note: ***, **, and * shows that the data is stationary and statistical significance at 1%, 5% and 10% significance level respectively.

4.6. ARDL Bounds Test for Cointegration

The autoregressive distributed lag (ARDL) bound test is a statistical tool used to assess the cointegration among the dependent and independent variables when there is a combination of I (0) and I (1) integration levels. Given that the F-statistic value is greater than both the lower and upper bounds in table 4.6.1., the null hypothesis of no cointegration is rejected, indicating the presence of a long-term connection or cointegration.

Table 4.11. ARDL BOUNDS TEST FOR COINTEGRATION

F-Statistics			
Country	**PAR**	**PANR**	**TI**
Brazil	I(0)	6.17164***	7.18796***
China	17.231***	8.08923***	12.2699***
India	9.05965***	4.25728***	4.73039***
Russia	12.1900***	5.01565***	5.38681***
SA	7.21674***	I(0)	6.07642***
Note: ***, **, and * shows the null hypotheses of no cointegration is rejected at 1%, 5% and 10% significance level respectively. The upper limit and lower limit is in Apendex A Table: 5.1			

In the above table 4.6.1. the results of the ARDL bound test performed on the PAR, PANR, MP, FD, GDPPC, GDPG, ER, and TRADE variables are shown. At all significance levels, the null hypothesis of no cointegration is rejected as the F-statistic value exceeds both the lower and upper limit critical values. Indeed, there is substantiated proof of cointegration. Given that Brazil's PAR and South Africa's PANR's data-dependent variable is integrated at I (0), there is no need for a bound test. Only the ARDL test will be used.0 The next step is to analyze the short-term and long-term correlation between the dependent and independent variables using level equations and ECM.

4.7. Patents by Residents

The results presented in Table 4.7 provide both long-term and short-term estimates obtained from the ARDL (Autoregressive Distributed Lag) model for Brazil, China, India, Russia, and South Africa. These results show the relationship between monetary policy, financial development, gross domestic product per capita, and trade with the dependent variable patents by residents. These results are analyzed with the connection to the previous studies to provide a deeper understanding for each country.

Table 4.12. ARDL Long and Short-Run Estimates for PAR: A Comparative Analysis for BRICS Countries

ARDL Long and Short-run Estimates					
Long-Run Estimation					
Variables	**Brazil**	**China**	**India**	**Russian**	**SouthAfrica**
MP	**I(0) ARDL**	-3.795 (1.209)**	-5.519 (2.907)*	0.070 (0.013)***	-2.565 **(**0.693)***
FD		21.544 (24.411)	1.233 (1.831)	0.441 (0.084)***	-0.008 **(**0.001)
GDPPC		1.057 (0.065)*	0.076 (0.021)*	0.071 (0.018)***	0.641 **(**0.339)*
TRADE		3.893 (5.913)	1.060 **(1**.125)	-0.400 (0.211)*	2.533 **(**0.941)**
Short-Run Estimations					
D (MP)	-0.089 (0.102)	0.452 (0.069)***	-0.078 (0.031)**	0.105 (0.011) ***	-1.388 (0.327)***
D (MP (-1))	0.104 (0.108)	-0.365542 (0.081477)***	-0.098 (0.024)***		
D(FD)	0.0073 (0.0556)	-2.828 (0.449)***	-0.1092 0.2218)	0.417 (0.135)***	-0.0053 (0.0078)
D (FD (-1))	0.0327 (0.056)	-0.396 (0.312)	-0.593 (0.322)**		
D (GDPPC)	-0.0371 (0.0382)	1.5334 0.0466)***		0.109 (0.0183) ***	0.135 (0.069)***

Table 4.12. (cont.)

D (GDPPC (-1))	-0.0286 (0.0334)	0.9052 0.0719)***			
D(TRADE)	-0.0286 0.1325	1.5334 (0.2520)***	0.345 0.155)**	-1.249 (0.321) ***	1.541 (0.662)**
D (TRADE (-1))	0.060350 (0.1444)	0.905222 (0.251535)***	0.382 (0.134)***		
CointEq (-1) *		-0.081 (0.012)***	-0.0187 (0.0023)***	-0.4532 (0.2521)***	-0.6364 (0.1353)***

Note: The figures in parenthesis represent the standard deviation. ***, **, and * shows that the variable is significant at 1%, 5% and 10% significance level respectively and D(-1) represents the differenced values and values represents no of lags.

The ADF test shows that the data for Brazil is integrated and stationary at level, and no cointegration exists. The ARDL model is employed to examine the short-run relationships between the variables. Table 4.7 shows the short-run results from the ARDL model for Brazil, and it shows an insignificant relation with MP and FD due to restrictive monetary policy and high inflation as a result of trade restrictions.

For China, the negative and statistically significant coefficient (-3.795) indicates that MP has a significant influence on innovation expenditure among residents, suggesting that higher interest rates hinder economic and innovation expansion in developing markets in the long run, and the results align with Majeed et al. (2024) and Ma & Zimmermann (2023). Its impact is the same in the short run, but it extends into the long run. Conversely, the substantial positive coefficient (14.756) of FD reflects the crucial role of financial sector expansion in driving economic growth among residents, supporting the "finance-led growth hypothesis," which posits that a more developed financial sector fosters economic growth by efficiently allocating resources (King & Levine, 2003). but it's significantly negative-related in the short run. The positive effect of GDP per capita (GDPPC) (1.057) and trade (3.896) aligns with the view that rising income levels enhance consumer spending (Barro, 1996), and trade supports the argument that integration into global markets drives productivity and innovation (Frankel & Romer, 2009) in both the long run and short run.

For India, the results show that the long-run negative and significant impact of MP on innovation (-5.519) aligns with the findings of Bose (2002), suggesting that higher interest rates hinder economic expansion in developing markets. In the short run, MP also shows a negative impact (-0.078), corroborating Keynesian views on contractionary policies (Keynes, 1936). Financial development (FD) positively

influences growth in the long run (1.233), in line with the finance-growth nexus literature (Levine, 2005), and negatively related in the short run due to little knowledge among the individuals. Trade openness (TRADE) and GDPG have a positive impact in the long run, as the coefficients are (0.071) and (1.060), respectively, and in the short run, it is significantly positive but trade is insignificant.

In Russia, the long-run impact of MP is positive but insignificant (0.070), reflecting the potential ineffectiveness of policy adjustments in driving sustained growth, possibly due to structural constraints or policy uncertainty (Gurvich & Prilepskiy, 2015). but significant is short run. Financial development (FD) also shows a positive and significant effect (0.441), suggesting limited long-term benefits from financial sector improvements, likely due to Russia's relatively underdeveloped financial markets. The significant positive impact of GDP per capita (GDPPC) (0.071) indicates that rising income levels contribute to growth, consistent with standard growth theories (Solow, 1956). Trade openness (TRADE) has a significant negative effect (0.0400) due to explosive trade and international markets.

In South Africa, (MP) has a significant negative long-run and short-run impact (-2.565) and (-1.388), suggesting that restrictive (MP) negatively effects the dependent variable, possibly due to reduced consumer spending and investment (Aron & Muellbauer, 2007). Financial development (FD) shows no significant effect, which aligns with findings that South Africa's financial sector reforms have not yet translated into broad-based economic benefits (Levine et al., 2000). The positive impact of GDP per capita (GDPPC) (0.641) and (0.135) in the long run and short run, respectively, suggests that higher income levels contribute to growth, though the effect is modest. The significant positive effect of trade openness (TRADE) (2.533) and (1.541) aligns with Edwards (2001), who argues that trade liberalization has been crucial in supporting South Africa's growth by enhancing export opportunities and integrating the economy into global markets in both the short run and long run.

4.8. Patents by Non-residents

The following table displays the outcomes of the level equation and ECM calculation for the long-term and short-term correlations among the variables across all nations for the patent's applications by non-residents.

Table 4.13. ARDL Long and Short-Run Estimates for PANR: A Comparative Analysis for BRICS Countries

ARDL Long and Short-run Estimates					
Long-Run Estimation					
Variables	**Brazil**	**China**	**India**	**Russian**	**SouthAfrica**
MP	-1.414 (0.350) ***	0.420 (0.129)***	-0.098 (0.052)**	0.266 (0.067)***	**SR**
FD	-0.284 (0.244)	4.358 (0.313)***	0.898 (0.003)***	0.990 (0.434)*	
GDPG	0.215 (0.346)	1.071 (0.295)***	0.068 (0.147)*	0.209 (0.117)	
TRADE	-1.712 (0.019) **	1.178 **(**0.292)***	0.0327 (0.006)***	1.016 (1.436)	
ER	0.023 (0.009) **	-0.130 (-0.541)	0.338 (0.065)***	-0.693 (0.165)*	
Short-Run Estimations					
D(MP)	-0.290 (0.1346)**	0.0253 (0.052)	-0.165 (0.054)***	0.1449 (0.052)**	0.3862 (0.151)**
D(MP (-1))	0.458 (0.152)***		0.194 (0.068)**	0.223 (0.081)**	
D(FD)	-0.210 (0.075)**	0.821 (0.371)**		0.0818 (0.379)	-0.0007 0.0023
D(FD (-1))	0.110 (0.093)***			0.832 (0.286)**	
D(GDPG)	0.097 (0.043)**	0.112 0.071)	0.020 (0.048)*	0.083 (0.050)	0.0037 (0.0111)
D(GDPG(-1))	0.0037 (0.0341)	-0.4040 (0.106)***	-0.1897 (0.058)***	0.175 (0.089)***	0.0213 (0.0124)*
D(TRADE)	-0.150 (0.173)	-0.828 (0.297)**	-0.616 (0.415)	1.254 (0.730)**	0.804 (0.236)***
D(TRADE(1))	0.289 (0.195)			-0.821 (0.587)	
D(ER)	0.097 (0.051)	-1.248 0.296)***	-0.944 (0.446)**	-0.057 (0.212)	-0.545 (0.140)***
D(ER (-1))	0.003 (-0.134) **		-1.665 0.510)***	0.494 (0.213)*	
CointEq (-1) *	-0.464 (0.068) ***	-0.655 (0.077)***	-0.816 (0.114)***	-0.716 (0.314)***	

Note: The figures in parenthesis represent the standard deviation. ***, **, and * shows that the variable is significant at 1%, 5% and 10% significance level respectively and D(-1) represents the differenced values and values represents no of lags.

The results presented in Table 4.9 provide both long-run and short-run estimates obtained from the ARDL (Autoregressive Distributed Lag) model for Brazil, China,

India, Russia, and South Africa. These estimates shed light on the relationships between (MP), financial development (FD), GDP growth (GDPG), trade openness (TRADE), and exchange rate (ER) with the dependent variable PANR. The findings are analyzed in relation to the existing literature to provide a deeper understanding of the underlying economic dynamics for each country.

In the long run, Brazil tighter (MP) has a significantly negative impact on innovation among foreigners (-1.414), consistent with Mishkin (2009) and Reinhart and Rogoff (2010), who argue that higher interest rates increase borrowing costs and reduce consumer spending. In the short run, MP changes also show a negative impact (-0.290), which aligns with Taylor's (1993) theory on contractionary policies and is consistent with the long-term findings that restrictive monetary policies can reduce economic activity. The coefficient for FD is negative but not statistically significant (-0.284), which may reflect the relatively underdeveloped nature of Brazil's financial markets in the long run. In the short run, the lagged value is positively related. GDP growth is significant and positively related (0.097) in the short run but insignificant in the long run. Trade openness (TRADE) negatively impacts growth in the long run (-1.712), suggesting that while Brazil's economy might benefit from trade in the long term, immediate exposure to international competition can have adverse effects (Rodrik, 1998). The positive and statistically significant effect (0.023) suggests that exchange rate depreciation may positively impact the dependent variable, consistent with Edwards (1989), who finds that a weaker currency can enhance export competitiveness and FDI over the long term.

For China, the positive and statistically significant coefficient (0.420) indicates that MP positively influences the dependent variable in the long run. This is consistent with Xie (2012) and Prasad (2007), who emphasize China's unique monetary policy regime characterized by proactive intervention and lower volatility, which has supported stable growth. The substantial positive coefficient (4.358) of FD reflects the crucial role of financial sector expansion in driving economic growth, as documented by Arestis, Chortareas, and Magkonis (2015). This finding supports the "supply-leading" hypothesis, where financial development fosters economic growth (King & Levine, 1993). Trade openness (TRADE) and GDP growth (GDPG) have significant positive impacts (1.178 and 1.071, respectively), suggesting that China has greatly benefited

from its trade openness and high GDP growth rates, corroborating studies by Frankel and Romer (1999) and Wei (1995), but their short-term effects are less pronounced.

For India, the results show that the long-run negative impact of MP on innovation (-0.098) aligns with the findings of Bose (2002), suggesting that higher interest rates hinder economic expansion in developing markets. In the short run, MP also shows a negative impact (-0.165), corroborating Keynesian views on contractionary policies (Keynes, 1936). Financial development (FD) positively influences growth in the long run (0.898), in line with the finance-growth nexus literature (Levine, 2005). Trade openness (TRADE) and GDPG have a positive impact in the long run (0.0327) and (0.068), respectively, and in the short run, they are significantly positively related in the short term, while exchange rate (ER) shows significant positive short-term effects, indicating market sensitivity to currency fluctuations (Joshi & Little, 1996).

Russia's long-run estimates show that MP positively affects growth (0.266), consistent with findings that controlled monetary policies can stabilize economies during volatility (Oomes & Ohnsorge, 2005). In the short run, MP also has a positive effect (0.1449), reflecting short-term stabilization efforts (Korhonen & Mehrotra, 2009). Financial development (FD) shows a positive relationship in the long run (0.990), aligning with literature on the importance of financial sector development in transition economies (Fry, 1997) and also significant in the short run (0.0818). GDPG and trade are significant in the short run and positively related but insignificant in the long term due to unpredictable conditions. However, exchange rate (ER) volatility has a negative impact both in the long run (-0.693), underscoring the challenges of managing currency fluctuations (Calvo & Reinhart, 2002). that exchange rate appreciation negatively impacts the dependent variable, consistent with Edwards (1989), who finds that a weaker currency can enhance export competitiveness and support growth over the long term and vice versa.

The ADF test shows that the data for South Africa is stationary at level; the ARDL model is employed to examine the short-run relationships between the variables. Table 5.7 shows the short-run results from the ARDL model for South Africa reveal several key economic dynamics. (D(MP)) have a positive and statistically significant effect with coefficent (0.3862) on innovation expenditures, consistent with the literature

suggesting that policy adjustments can help stabilize inflation expectations and bolster short-term economic performance (Taylor, 1993; Mishkin, 2009). In contrast, the impact of financial development (D(FD)) is not statistically significant. GDPG lagged value is positively and significant (0.0213) which shows that increase in the GDP of previous years is impacting future expenditures. Trade openness (D(TRADE)) exerts a strong positive influence (0.804), aligning with studies that highlight the immediate growth benefits of trade liberalization (Edwards, 2001; Frankel & Romer, 1999). Conversely, changes in the exchange rate (D(ER)) demonstrate a significant negative impact with coefficient (-0.545), indicating that currency appreciation poses short-term challenges, such as increased import costs and inflationary pressures (Calvo & Reinhart, 2002).

4.9. Technological Innovation

The following table displays the outcomes of the level equation and ECM calculation for the long-term and short-term correlations among the variables across all nations for the technological innovation (sum of residents and nonresidents).

Table 4.14. ARDL Long and Short-Run Estimates TI: A Comparative Analysis for BRICS Countries

ARDL Long and Short-run Estimates					
Long-Run Estimation					
Variables	**Brazil**	**China**	**India**	**Russian**	**SouthAfrica**
MP	-1.080 (0.255) ***	-2.420 (0.129)***	-0.100 (0.136)*	0.180 (0.029)***	-0.418 0.240)*
FD	-0.167 (0.151)	4.358 **(**0.313)***	0.731 (0.393)*	0.367 (0.101)***	-0.488 (0.248)*
GDPG	0.164 (0.124)	1.071 (0.295)***	0.065 (0.034)*	0.099 (0.046)*	0.017 (0.015)*
TRADE	-1.089 (0.425) **	1.178 (0.292)***	0.022 (0.011)*	0.103 (0.367)	1.102 (0.296)
ER	0.026 (0.007)	-0.130 (0.242)		-0.392 (0.056)***	-0.066 (0.094)
Short-Run Estimations					
D (MP)	-0.200 (0.101) *	-0.183 (0.051)***	-0.112 (0.047)**	0.158 (0.018) ***	-0.003 (0.010)
D (MP (-1))	0.321 (0.114) **	0.140 (0.041)***			0.006 (0.009)***
D(FD)	-0.145 (0.059) **		0.843 0.538)	0.007 0.126)	-0.002 (0.003)
D (FD (-1))	0.126 (0.072) *			-0.493 (0.152) **	-0.006 (0.004)

Table 4.14. (cont.)

D (GDPG)	0.061 (0.034) *	0.143 0.064)**	-0.167 0.6770)	0.1072 (0.017) ***	-0.011 (0.0139)
D (GDPG (-1))	-0.013 (0.026)	0.276 0.076)***		0.035 0.013	0.017 (0.015)*
D (Trade)	-0.087 (0.136)	-0.468 (0.2798)	0.000545 0.008653)		1.878 (0.555)***
D (Trade (-1))	0.217 0.154)				0.576 (0.444)
D(ER)	-0.051 (0.039)			-0.008 0.097)	-0.185 (0.277)
D(ER(-1))	-0.079 (0.043) *			0.260 (0.093)**	-0.294 (0.262)
CointEq(-1)*	(-0.390) (0.031)**	-0.341 0.029)***	-0.609 (0.130)***	-1.264 (0.178) ***	-0.774 (0.148)***

Note: The figures in parenthesis represent the standard deviation. ***, **, and * shows that the variable is significant at 1%, 5% and 10% significance level respectively and D(-1) represents the differenced values and values represents no of lags.

The results presented in Table 4.8 provide both long-run and short-run estimates obtained from the ARDL (Autoregressive Distributed Lag) model for Brazil, China, India, Russia, and South Africa. These estimates shed light on the relationships between (MP), financial development (FD), GDP growth (GDPG), trade openness (TRADE), and exchange rate (ER) with the dependent variable TI. The findings are analyzed in relation to the existing literature to provide a deeper understanding of the underlying economic dynamics for each country.

For Brazil, both the long-run and short-run estimates indicate a negative impact of MP on TI. In the long run, the effect is significantly negative (-1.080), suggesting that restrictive policies hinder economic performance over time. In the short run, changes in MP (D(MP)) also negatively impact growth (-0.200), but past adjustments (D(MP(-1))) show a positive effect (0.321), indicating some delayed positive outcomes from prior policy changes. Financial development (FD) shows an insignificant effect in the long run, while in the short run, immediate changes in FD (D(FD)) have a negative impact (-0.145), with a slight positive lagged effect (D(FD(-1)) = 0.126). GDP growth (GDPG) contributes positively in both periods, suggesting that growth momentum sustains itself. Trade openness (TRADE) shows a negative impact in the long run (-1.089), reflecting potential downsides of exposure to global competition with insignificant short-run effects.

For China, macroeconomic policy (MP) has a consistently negative impact in both the long run (-2.420) and short run (D(MP) = -0.183), indicating that restrictive monetary policy measures can constrain growth over both periods. Financial development (FD) is highly significant and positive in the long run (4.358), underscoring its importance for sustained growth. However, short-run changes in FD are not significant, suggesting that immediate financial changes may not produce quick results. GDP growth (GDPG) positively affects growth in both the long run (1.071) and short run (D(GDPG) = 0.143), reinforcing the role of continuous economic expansion. Trade openness (TRADE) positively influences long-term growth (1.178), while short-run effects are mixed and less pronounced.

In India, restrictive (MP) policies have a negative impact in both the long run (-0.100) and short run (D(MP) = -0.112), consistent with the view that such policies can stifle innovation. Financial development (FD) has a positive and significant impact in the long run (0.731), highlighting its role in driving growth, but short-run changes are insignificant. (GDPG) has a positive impact in the long run (0.065) but shows a mixed impact in the short run, with some negative short-term adjustments. Trade openness (TRADE) has a small positive effect in the long run (0.022) and is largely insignificant in the short run.

For Russia, macroeconomic policy (MP) positively affects growth in the long run (0.180), indicating that supportive policies can drive long-term economic performance. In the short run, MP changes (D(MP)) also have a positive impact (0.158), suggesting both immediate and sustained benefits from such policies. Financial development (FD) positively impacts growth in the long run (0.367), but short-run effects are mixed, with significant negative lagged effects (D(FD(-1)) = -0.493). GDP growth (GDPG) contributes positively in both the long run and short run, highlighting the importance of economic momentum. Trade openness (TRADE) is insignificant in the long run, but short-run changes show a strong positive effect (D(TRADE) = 1.878), indicating benefits from immediate increases in trade activity.

For South Africa, macroeconomic policy (MP) negatively affects growth in both the long run (-0.418) and short run, though the short-run effect is not significant. Financial development (FD) shows a negative impact in the long run (-0.488), suggesting that

current financial conditions may not be conducive to growth, while short-run effects are insignificant. GDP growth (GDPG) has a positive but small impact in both periods, indicating its consistent but limited role in supporting growth. Trade openness (TRADE) has a positive but insignificant impact in the long run and a significant positive effect in the short run (D(TRADE) = 1.878), suggesting immediate gains from increased trade.

CHAPTER V

CONCLUSIONS

The study's goal is to clarify the importance of monetary policy and financial development, as well as their influence on promoting innovation among residents and nonresidents. We use the ARDL model and ECM model statistical techniques to measure the impact in both the short and long run. Sometimes variables don't have an immediate impact, and it takes some time for them to have a significant influence in the long run, as people tend to prioritize future outcomes. We gather a yearly data set from WDI for the BRICS countries from 1998 to 2021, depending on the availability of data.

Patents play a critical role in promoting innovation and serve as an indicator of a country's innovation, reflecting its role in technological advancement and economic expansion. They safeguard novel techniques, promote creativity, encourage innovation, and encourage investment for long-term benefits. Central banks set monetary policy to achieve macroeconomic objectives, which in turn creates an environment that encourages people to invest more in innovation. Financial development reflects the advancement of financial instruments and markets for the effective transmission of monetary policy and the promotion of the optimal allocation for innovation.

Monetary policy and financial development are important variables that drive technological innovation in emerging countries and lead to economic growth. Increasing the real interest rate negatively affects residents' innovation expenditure, making it more costly to invest in small startups. This implies that rising interest rates impede the growth of economics and innovation in emerging countries, while financial development plays a crucial role in bolstering the finance-led growth theory. Increases in GDP, trade, and GDPC positively correlate with an increase in innovation expenditures.

The contractary monetary policy, with its unique characteristics of proactive intervention and lower volatility, can sometimes positively influence the patents of nonresidents, thanks to the large investment market and stable GDP. Financial development always promotes innovation among nonresidents. Deprivation of currency creates an attractive environment for investment, but sometimes it's insignificant due to other factors. In Brazil, the lack of integration and typically high interest rates make it difficult for individuals to obtain bank financing, which in turn renders monetary policy insignificant in terms of innovation.

This research has some limitations. The study concentrated on examining the influence of independent variables on dependent variables in both short- and long-term relationships, utilizing time series data. The new studies should use some different measure of innovation and monetary policy and can also study the interplay between these variables to study the casual observations.

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APPENDIXES

APPENDEX A

Table A.1. Upper and Lower Limit Bounds Test

BRAZIL

	PAR		**PANR**		**TI**	
Signif	**I(0)**	**I(1)**	**I(0)**	**I(1)**	**I(0)**	**I(1)**
10%			2.26	3.35	2.26	3.35
5%			2.62	3.79	2.62	3.79
2.5%			2.96	4.18	2.96	4.18
1%			3.41	4.68	3.41	4.68
F-Stat			6.171640		7.187957	
K			5		5	

CHINA

	PAR		**PANR**		**TI**	
Signif	**I(0)**	**I(1)**	**I(0)**	**I(1)**	**I(0)**	**I(1)**
10%	1.9	3.01	2.2	3.09	2.26	3.35
5%	2.26	3.48	2.56	3.49	2.62	3.79
2.5%	2.62	3.9	2.88	3.87	2.96	4.18
1%	3.07	4.44	3.29	4.37	3.41	4.68
F-Stat	17.23096		8.08923		12.2699	
K	4		3.9		4.5	

INDIA

	PAR		**PANR**		**TI**	
Signif	**I(0)**	**I(1)**	**I(0)**	**I(1)**	**I(0)**	**I(1)**
10%	2.2	3.09	1.81	2.93	2.26	3.35
5%	2.56	3.49	2.14	3.34	2.62	3.79
2.5%	2.88	3.87	2.44	3.71	2.96	4.18
1%	3.29	4.37	2.82	4.21	3.41	4.68
F-Stat	9.059655		4.257282		4.730385	
K	4.		5		5	

RUSSIA

	PAR		PANR		TI	
Signif	**I(0)**	**I(1)**	**I(0)**	**I(1)**	**I(0)**	**I(1)**
10%	2.68	3.53	2.26	3.35	2.26	3.35
5%	3.05	3.97	2.62	3.79	2.62	3.79
2.5%	3.4	4.36	2.96	4.18	2.96	4.18
1%	3.81	4.92	3.41	4.68	3.41	4.68
F-Stat	8.294193		5.015649		5.386811	
K	4		5		5	

SOUTHAFRICA

	PAR		PANR		TI	
Signif	**I(0)**	**I(1)**	**I(0)**	**I(1)**	**I(0)**	**I(1)**
10%	3.03	4.06			2.26	3.35
5%	3.47	4.57			2.62	3.79
2.5%	3.89	5.07			2.96	4.18
1%	4.4	5.72			3.41	4.68
F-Stat	7.216742				6.076420	
K	4				5	

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