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Testing long-run neutrality of money in Slovakia

Bachelor's thesis

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Declaration of Authorship

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Prague, July 22, 2024

Daniela Žigová

Abstract

Does money matter? This thesis investigates the long-run neutrality of money in Slovakia using the Fisher and Seater methodology applied to quarterly data from 1996 to 2023. The study tests the neutrality hypothesis by examining the relationship between monetary aggregates M1, M2, and M3, and real GDP. A diagnostic augmented Dickey-Fuller test for unit roots confirms that the neutrality test is applicable, with M1 identified as suitable for superneutrality testing due to its order of integration. The findings reveal that money is not neutral in Slovakia considering all three monetary aggregates. When M1 is the criterion, the superneutrality of money cannot be rejected. These results imply that monetary policy can effectively influence real economic variables, highlighting its importance for economic stability even within the Eurozone context post-2009. The thesis suggests several avenues for future research, including the impact of money supply changes on price levels.

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Abstrakt

Mají peníze význam? Tato bakalářská práce zkoumá dlouhodobou neutralitu peněz na Slovensku pomocí metodologie Fisher a Seater aplikované na čtvrtletní data z let 1996 až 2023. Studie testuje hypotézu neutrality zkoumáním vztahu mezi měnovými agregáty M1, M2 a M3 a reálným HDP. Diagnostický test pro jednotkové kořeny potvrzuje, že test neutrality je použitelný, přičemž M1 je identifikován jako vhodný pro testování superneutrality díky svému řádu integrace. Zjištění ukazují, že peníze na Slovensku nejsou neutrální vzhledem ke všem třem měnovým agregátům. Když je kritériem M1, superneutralitu peněz nelze zamítnout. Tyto výsledky naznačují, že měnová politika může účinně ovlivňovat reálné ekonomické proměnné, což zdůrazňuje její význam pro ekonomickou stabilitu i v kontextu eurozóny. Práce navrhuje několik směrů pro další výzkum, včetně dopadu změn v peněžní zásobě na cenovou hladinu.

Klasifikace JEL	C32, C54, E41, E51
Klíčová slova	neutralita peněz, měnová politika, jednotkový kořen, peněžní zásoba
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Acronyms

FS Fisher and Seater

VAR vector autoregressive

LRN long-run money neutrality

LRSN long-run money superneutrality

ARIMA autoregressive integrated moving average

ADF augmented Dickey-Fuller

GDP Gross Domestic Product

OLS ordinary least squares

NBS National Bank of Slovakia

ECB European Central Bank

Chapter 1

Introduction

Is it the case that money supply solely impacts nominal variables and does not exert any influence on real variables in the long-run? Put simply, is money considered neutral? This question has captivated economists across generations and continues to be a subject of ongoing interest. Consider the two primary hypotheses explaining this relationship: long-run money neutrality (LRN) and long-run money superneutrality (LRSN). The neutrality of money refers to the idea that a permanent change in the *level* of money has no effect on real economic variables in the long-run (Sulku 2011). In addition, the LRSN hypothesis suggests that a permanent change in the *growth rate* of the money supply does not affect the level of real variables in the long-run. While some macroeconomic models do allow for short-run non-neutrality, LRN is universally recognized as an axiom within the field (Bullard 1999), even though empirical findings are not unambiguous. On the other hand, the long-run superneutrality exhibits a notably more cautious stance, and it is not surprising that departures from this hypothesis are quite common among economists (Bullard 1999). The reason why the neutrality of money is an important topic in macroeconomics is due to its direct impact on the effectiveness of monetary policy. Its acceptance or rejection can guide monetary authorities when choosing appropriate policies and tools before full implementation, as this process can be quite costly. Thus, it is beneficial to investigate the neutrality proposition in the economy of every country (Iranmanesh & Jalaee 2021). This thesis tests the hypothesis of long-run neutrality and superneutrality for the case of Slovakia.

Prior to Slovakia's adoption of the euro currency, the National Bank of Slovakia (NBS) held sole responsibility for all monetary policy decisions within the country. The NBS's monetary policy history can be delineated into two

distinct stages. The initial stage, spanning from 1993 to 1999, was characterized by independent monetary policy decisions made by the NBS. Subsequently, the second stage, encompassing the period from 2000 to 2008, witnessed the NBS endeavoring to align its monetary policy decisions with those of the European Central Bank (ECB) (National Bank of Slovakia 2024).

Slovakia formally embraced the euro as its official currency on January 1, 2009, thereby becoming the 16th member of the Eurozone (National Bank of Slovakia 2024). Consequently, the NBS became integrated into the European System of Central Banks, closely coordinating its monetary policy with the ECB.

The implementation of macroprudential policy in Slovakia is notably influenced by its participation in the Single Supervisory Mechanism, with shared responsibility for this policy between national authorities and the ECB. The ECB is authorized to augment the requirements established by national authorities' decisions but not to diminish them (National Bank of Slovakia 2024).

The Eurosystem carries out monetary policy through an operational framework comprising various monetary policy instruments and procedures. These are applied uniformly in a decentralized manner through the ECB and the national central banks of the Eurosystem, including NBS (National Bank of Slovakia 2024).

In coordination with the NBS, the ECB utilizes several key instruments to execute monetary policy, including minimum reserve requirements and open market operations, wherein the ECB provides loans to address the liquidity needs of the banking sector (Kochanová 2008).

Though Slovakia is integrated into the Eurozone and lacks its independent monetary policy, evaluating its neutrality is essential for gaining insights into Slovakia's specific dynamics within the Eurozone. The results can provide an understanding of how monetary policy impacts real economic variables within small, open economies integrated into a larger monetary union.

Following the money neutrality proposition that changes in the stock of money affect only the nominal variables, leaving the real variables unchanged, this thesis, therefore, aims to answer the following questions: Do changes in all three monetary aggregates, M1, M2, and M3, have no significant influence on the development of real output, represented by Gross Domestic Product (GDP), in the long-run? Does money matter in Slovakia? In other words, the objective of this thesis is to empirically test the long-run neutrality of money in Slovakia using the Fisher & Seater (1993) methodology. Fisher & Seater

(1993) conducted appropriate long-run neutrality tests within a multivariate autoregressive integrated moving average (ARIMA) framework that required little macroeconomic structure. This method is relevant to our thesis as empirical tests of long-run neutrality are often challenging to interpret due to the necessity of assumptions about the underlying economic structure. As a result, Fisher & Seater (1993) approach, which imposes minimal requirements for macroeconomic structural assumptions, offers greater adaptability and reduced reliance on specific economic theories.

This thesis makes a contribution to the ongoing discourse and existing literature on the neutrality of money by conducting empirical tests from the unique vantage point of Slovakia. With a focus on practical applications and real-world implications, the findings of this thesis have the potential to inform policy decisions and contribute to the broader body of knowledge in this field in the specific context of Slovakia.

This thesis is structured as follows: Chapter 2 provides an overview of previous empirical studies in this field and reviews the theoretical foundations of money neutrality, focusing on the perspective of different schools. Chapter 3 outlines the methodology used in this study, detailing the Fisher and Seater (FS) approach. Chapter 4 describes the quarterly available time series data, including the selection of monetary aggregates and real output measure, and discusses data properties. Chapter 5 presents the empirical findings and discusses their policy implications for the Slovak economy in the broader Eurozone context. Finally, in Chapter 6, we summarize the key findings, address potential limitations, and suggest areas for future research.

Chapter 2

Literature Review

This section aims to summarize the key empirical studies and findings on money neutrality. The studies have produced diverse conclusions, varying across different countries and time intervals. Firstly, we will provide a theoretical background to better understand the key concepts presented in this thesis. Secondly, we will focus on methodological varieties for testing money neutrality. However, we will not discuss the econometric propositions in detail as this will be covered in Methodology (Chapter 3). This section also presents results from several papers to illustrate the varying outcomes based on different factors.

2.1 Money In Different Schools

2.1.1 Classical School

In classical theory, money's significance has been downplayed. The argument is that monetary forces do not impact the real variables, such as output or employment (Puah et al. 2008). Money neutrality holds in the classical theory, and the real variables like real interest rate, real exchange rate, production, or employment are determined independently of changes in the money supply (Iranmanesh & Jalaee 2021).

2.1.2 Keynesian School

Keynesian theory, developed by John Maynard Keynes, is a macroeconomic theory that places significant emphasis on the role of monetary policies in regulating economic activity. The theory suggests that there are three primary

motives for maintaining money: trading, speculation, and precautionary (Iranmanesh & Jalaee 2021).

Trading refers to the use of money to engage in transactions, such as buying goods and services. Speculation involves investing money in the expectation of future gains, such as buying stocks or real estate. Precautionary motive, on the other hand, refers to holding money as a precaution against unexpected events, such as a job loss or medical emergency.

Keynesians believed that money was not neutral and that changes in the money supply could have significant impacts on the economy (Iranmanesh & Jalaee 2021). According to their theory, an increase in the money supply would lead to lower interest rates, which would increase investment and consumer spending, leading to higher output and employment. Conversely, a decrease in the money supply would lead to higher interest rates, which would reduce investment and consumer spending, leading to lower output and employment.

Overall, the Keynesian theory placed a significant emphasis on the role of government intervention in regulating economic activity. The theory suggested that monetary policies, such as changes in the money supply and interest rates, could be used to stabilize the economy and promote economic growth.

2.1.3 Monetarist School

Monetarism is an economic theory that emphasizes the role of money supply in economic growth and stability (Puah et al. 2008). Monetarists, led by Milton Friedman, believe that in the long-run, there is a clear distinction between the real and monetary sectors. According to this theory, the long-term trend of the economy is determined by real factors such as technology, productivity, and resources. However, in the short run, nominal shocks can have an impact on real variables (Iranmanesh & Jalaee 2021).

This means that classical theory is accurate as long as money can influence real variables in the short term, but in the long-run, money neutrality prevails (Iranmanesh & Jalaee 2021). In other words, the money supply does not affect real economic variables such as output, employment, and interest rate. Instead, it only affects the price level and inflation.

Monetarists argue that monetary policy should be used to control inflation in the short run, but not to stimulate economic growth. They believed in the self-balancing feature of the economy (Iranmanesh & Jalaee 2021).

Overall, monetarism has had a significant influence on macroeconomic the-

ory and policy. Its emphasis on the role of money supply in the economy has led to the development of new tools and techniques for monetary policy.

2.1.4 New Classical School

New classical economists argue that the anticipated increase in the money supply cannot influence production and employment. However, as suggested by Lucas Jr (1972), unanticipated money supply changes can impact the economy in the short run. This means that while money is superneutral in the long run, unanticipated monetary shocks can have short-term effectiveness (Iranmanesh & Jalaee 2021).

The new classical approach emphasizes the importance of expectations in determining economic outcomes. According to this view, individuals form their expectations based on the information available to them, including past experience and current economic conditions. This means that if individuals expect a certain level of inflation, for example, they will adjust their behavior accordingly.

In contrast, unanticipated changes in the money supply can catch individuals off guard, leading them to adjust their behavior in a way that can impact economic activity in the short run. For instance, if the money supply suddenly increases, individuals may feel wealthier and increase their spending, which can lead to an increase in production and employment. On the other hand, if the money supply suddenly decreases, individuals may cut back on their spending, which can lead to a decrease in production and employment.

Overall, the new classical approach provides a nuanced understanding of the role of money in the economy. While money is superneutral in the long run, unanticipated monetary shocks can have short-term effectiveness. Therefore, policymakers need to take into account the expectations of individuals when setting monetary policy to avoid unexpected shocks that can lead to undesirable economic outcomes.

2.2 Long-Run Money Neutrality

Long-run money neutrality is a highly significant concept in macroeconomics that postulates that changes in the money supply do not have any permanent effect on real output in the long run. It is a fundamental principle that helps to understand the relationship between money and the economy. In simple terms,

the long-run neutrality of money implies that changes in monetary aggregates like M1 and M2 do not affect the development of real variables in the long run (Bullard 1999).

It is important to note that the concept of long-run neutrality of money applies only to the long term and not the short term. In the short run, changes in the money supply can have a significant impact on the economy's behavior. However, in the long run, the effects of monetary policy are limited to nominal variables, such as prices and inflation rates.

According to Bullard (1999), there is relatively little debate among economists regarding the merits of long-run neutrality. It is a widely accepted concept that is taken almost as an axiom. However, it is important to note that changes in the money supply need to be unexpected to have any significant effect on the economy. If the economy's participants anticipate changes in the money supply, they may adjust their behavior, which can mitigate the effects of monetary policy.

2.3 Long-Run Money Superneutrality

As we discussed in the previous section, long-run money neutrality refers to the idea that a permanent change in the level of the money stock will have no impact on the level of real output. On the other hand, superneutrality pertains to the notion that a permanent change in the growth rate of money supply will have no impact on the level of real variables in the long-run (Sulku 2011). This implies that changes in the rate at which the money supply increases do not affect the long-term growth of the economy, allowing real output to remain unaffected by such changes. While long-run neutrality is widely accepted in monetary economics, long-run superneutrality is approached more cautiously. Finding empirical evidence that clearly demonstrates deviations from long-run superneutrality would not be too unexpected, considering the complexity of this concept. The preceding statement underscores a key insight brought forth by Bullard (1999): the potential deviation from long-term monetary superneutrality due to the impact of monetary growth on inflation and its resultant distortive effects. The implication is that a sustained adjustment in the rate of monetary expansion may yield enduring repercussions for the real economy. In other words, if monetary growth leads to inflation and inflation has distorting effects, then long-term monetary superneutrality might not hold in reality (Bullard 1999).

2.4 The Quantity Theory of Money

The Quantity Theory of Money connects the quantity of nominal money to the real GDP and price level:

$$mv = py. \tag{2.1}$$

Where m is the quantity of money, v is the transaction velocity of money, and $P \times Y$ is the nominal output (Arintoko 2011). According to the quantity equation, an increase in the money supply corresponds to an increase in one of three variables: output, prices, or a decrease in money velocity, with velocity typically remaining stable (Arintoko 2011). When the Central Bank injects money into the economy and changes the money supply, nominal output proportionally changes. Money neutrality implies that changes in money supply (variations in m) do not affect real output, y, but rather impact prices, p (Arintoko 2011). In other words, when discussing long-run monetary neutrality, economists contemplate a theoretical experiment involving a sudden, permanent, and unforeseen change in the money stock. According to the quantity theory of money, this would eventually lead to proportional price increases, with real variables returning to their original levels. However, in real-world economies, distinguishing between "highly persistent" and "permanent" changes is challenging, despite the use of empirical tests (Bullard 1999).

Most monetary theories assume long-run monetary neutrality, where real variables eventually revert to their initial states after such monetary shocks.

2.5 Empirical approaches

Fisher & Seater (1993) ARIMA framework and King & Watson (1992) vector autoregressive (VAR) methodology are two notable studies concerning the time-series properties of output and money aggregates. A discussion paper titled "Testing Long-Run Monetary Neutrality Propositions: Lessons from the Recent Research" by Bullard (1999) provides a comprehensive overview of those two econometric frameworks that can be used to test LRN of money. As Bullard (1999) suggests, Fisher & Seater (1993) and King & Watson (1992) provided new tests of LRN propositions that require little macroeconomic structure. Reduced form tests derived by FS do not necessitate specific assumptions regarding the underlying economy's organization.

Reduced form tests of money neutrality derived by FS stand on the order

of integration of both output and monetary aggregates. Order of integration is defined by various possible tests, including augmented Dickey-Fuller (ADF) which is most commonly used. However, as Bullard (1999) pointed out, those unit root diagnostic tests that classify macroeconomic variables into those that are subject to permanent shocks and those that are not, have limited power. To test LRN of money, both money and real output should be non-stationary. In other words, money and output are subject to permanent shocks. Further, King & Watson (1992) pointed out the inefficiency of money neutrality tests in the presence of cointegration between the variables. In other words, when variables are expected to move together over time in the long run. We will discuss further econometric issues in Chapter 3.

2.6 Previous findings

By using VAR model, King & Watson (1992) tested the LRN in the USA within 1949 - 1990. They found little evidence against the long-run neutrality proposition in their data while the sign and magnitude depended critically on the specific identifying restriction.

Using USA data as well, Boschen & Otrok (1994) discovered consistency with the hypothesis of LRN, however, only when modifying the equation by adding intercept dummies for the period of the Great Depression. The reason for this procedure is the abnormal level of money supply shocks during the depression period. The main purpose of their work was to reexamine Fisher & Seater (1993)'s empirical findings on LRN of money and show that their results were driven by the decade of the Great Depression.

In his study, Weber (1994) analyzed quarterly data for the G7 countries, which includes Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States. The research findings indicate that for broader monetary aggregates, there is insufficient evidence to reject the concept of long-run monetary neutrality in the G7 economies. However, it is important to note that the principle of superneutrality was not upheld across the board - it was found to be rejected in all of the countries under study. This suggests that while changes in the money supply may not have a lasting impact on real variables in the long run, they do exert a short-term influence that is significant enough to impact the economy in the shorter term.

Malliaropulos (1995) used United Kingdom data for 1965 to 1994 and found that those data support the LRN hypothesis concerning all series examined.

Olekalns (1996) used the Fisher & Seater (1993) approach on Australian data for 1900-1901 to 1993-1994. The results show that neutrality holds when M1 is the money measure but does not hold when broader money (M3) is analyzed. Furthermore, some of the US studies of money neutrality might have been affected by the events of the early 1930s. For this reason, Olekalns (1996)'s Australian experiment provides a useful comparison.

Using Fisher & Seater (1993)'s methodology, Bae & Ratti (2000) investigated LRN in Argentina and Brazil during 1884-1996 for Argentina and over 1912-1995 for Brazil. They concluded that money is long-run neutral but not long-run superneutral. Bae & Ratti (2000) analyzed annual observations on monetary aggregate M2, price level, and real output.

Shelley et al. (2003) showed that LRN is rejected in Mexico for the full sample period. However, rejection is the result of a downward shift in the mean growth rate of real GDP occurring in 1982. Neutrality is not rejected if one uses data only through 1981.

Fisher & Seater (1993) methodology was used by Noriega et al. (2008) who investigated money neutrality in Australia, Canada, Sweden, the UK, Argentina, Brazil, Mexico, and Italy using long annual data on real output and monetary aggregates (M2). For 6 of the 8 cases analyzed, LRN seems to hold.

Sulku (2011) tested the hypothesis of money neutrality in Turkey for 1987-2006 using FS approach and found that LRN holds in Turkey and the results are robust under all alternative monetary aggregates. The observed period in this paper is relatively short; however, there were sudden changes in money and prices which assures the possibility of controlling a long-run relationship.

Arintoko (2011) considered monetary aggregates M1 and M2 for Indonesia over the periods 1970-2008 and found that LRN of money does not prevail in the Indonesian case. Non-neutrality of money in Indonesia confirmed in this research is consistent with Puah et al. (2008) who used different observation periods, 1965 - 2002.

Haughton & Iglesias (2013) analyzed the issue of LRN in the Organization of Eastern Caribbean States by using the European Monetary Union and a group of other countries from the Caribbean as control groups. The results show that money is neutral for both control groups and the existence of a central bank in monetary unions is beneficial for the control of real economic variables.

Vaona (2015) analyzed the long-run connection between inflation and output in the Eurozone area, which is an interesting case study because of its monetary authority. She discovered a strong positive long-run connection be-

tween inflation and output using quarterly series concerning the GDP deflator and the GDP in 2005.

By using VAR model, Deev & Hodula (2016) investigated the money superneutrality concept for the panel of 29 European countries in the period of at least 29 years. The effect of a permanent inflation change on real output growth can be positive, negative, or negligible. If no response is found, Deev & Hodula (2016) declare the validity of the superneutrality concept using real GDP and inflation, approximated by the GDP deflator. For eighteen countries the long-run superneutrality concept is confirmed, seven countries have experienced a positive output response to a permanent inflation shock, while only one country has experienced a negative response.

So far not a lot of research has been done regarding the money neutrality proposition in Slovakia. However, Škare et al. (2016) examined 11 ex-socialist EU countries from 1995 to 2013, including Slovakia. They used the real output, two monetary aggregates (M1 and M2), and a relatively short time series, which creates some doubts about the accuracy of unit root and cointegration tests. In 2009, Slovakia adopted the euro as the national currency and became part of the eurozone. Authors feared that this might affect the analysis, however, this was not the case. It was concluded that money is not neutral in the long run.

Ugwu et al. (2021) and Ditimi & Ademola (2020) did not find overall support for the theory of LRN in Nigeria, both using the Vector error correction mechanism approach. The error correction model suggests that, for money to be wholly neutral in the long run, it will take one year and nine months. Furthermore, violation of the classical and monetarist dichotomies of monetary aggregates in Nigeria makes money neutrality testing unachievable.

Iranmanesh & Jalaee (2021) applied FS methodology to data for Iran during 1979-2018. This study investigated the neutrality principle specifically in the industry sector. When the monetary base is the criterion, money neutrality is confirmed, but when liquidity and money volume are the criteria, money neutrality is rejected.

Chapter 3

Methodology

In this chapter, underlying mathematical formulas and particular econometric procedures to test neutrality are described. The description of the Fisher & Seater (1993) method closely follows Olekalns (1996).

3.1 The Fisher-Seater Methodology

Fisher & Seater (1993) method is based on a bivariate, autoregressive depiction of money and output:

$$\theta(L)\Delta^k m_t = \phi(L)\Delta^l y_t + \varepsilon_t^1 \tag{3.1.0.1}$$

$$\gamma(L)\Delta^l y_t = \eta(L)\Delta^k m_t + \varepsilon_t^2 \tag{3.1.0.2}$$

where L is the lag operation, therefore m_t is log money and y_t is log output, Δ represents the first differences, k is the order of integration of the stock of money, m, l is the order of integration of the real output, y, and ε_t^1 and ε_t^2 are the error terms that are independently identically distributed with mean zero. Observing the extent to which a permanent money supply shock changes real output can test for long-run neutrality. This is measured by the long-run derivative of output with respect to a permanent change in money:

$$LRD_{y,m} = \lim_{j\to\infty} \frac{\frac{\partial y_{t+j}}{\partial \varepsilon_t^1}}{\frac{\partial m_{t+j}}{\partial \varepsilon_t^1}} \tag{3.1.0.3}$$

provided that

$$\lim_{j\to\infty} \frac{\partial m_{t+j}}{\partial \varepsilon_t^1} \neq 0$$

.

The last requirement ensures that the money supply is vulnerable to enduring shocks, which is necessary when testing for long-run neutrality. If the limit is zero then there are no permanent changes in the monetary variable and we cannot test for neutrality. Fisher & Seater (1993) define the long-run derivative as a ratio of two sequences. The sequence in the numerator measures the effect through time of an exogenous money disturbance on the variable y, and the sequence in the denominator measures the effect of the same money disturbance on the monetary variable, m. In a situation when the variables have the same order of integration, long-run derivative measures the long-run elasticity of y with respect to m. Fisher & Seater (1993) modify the form of the long-run derivative for different values of k and l. The main result is that LRN can only be adressed if $k \geq 1$ and $l \geq 1$.

As Malliaropulos (1995) pointet out, the most important case occurs when $k = l = 1$. In this case, $LRD_{y,m} = \eta(1)/\gamma(1)$, the long-run value of the impulse-response function of y with respect to m. In other words, the coefficient in the numerator represents the long-run response of the dependent variable (output) to a change in the independent variable (money supply).

Coefficient in the denominator of 3.1.0.3 captures the adjustment dynamics, so it reflects how quickly or slowly the output adjusts to changes in the money supply over time. Thus, when we say that $LRD_{y,m} = 0$, it means that $\eta(1)$, the long-run response coefficient, is zero. This implies that in the long-run, changes in money supply have no effect on output, which corresponds with the concept of LRN. Considering the restriction that money is exogenous in the long run, Fisher & Seater (1993) establish that $\eta(1)/\gamma(1)$ can be consistently estimated as β_j from the following regression:

$$\left[\sum_{i=0}^{j} \Delta^l y_{t-i}\right] = \alpha_j + \beta_j \left[\sum_{i=0}^{j} \Delta^k m_{t-j}\right] + \omega_{jt} \tag{3.1.0.4}$$

When $k = l = 1$, Fisher & Seater (1993) argue that consistent estimates of β_j can be derived by applying ordinary least squares (OLS) to the regression:

$$(y_t - y_{t-j-1}) = \alpha_j + \beta_j(m_t - m_{t-j-1}) + \omega_{jt}. \tag{3.1.0.5}$$

Super-neutrality can be tested if $l = 1$ and $k = 2$ by estimating β_j from the regression:

$$(y_t - y_{t-j-1}) = \alpha_j + \beta_j(\Delta m_t - \Delta m_{t-j-1}) + \omega_{jt}. \quad (3.1.0.6)$$

3.2 Integration

Before applying the Fisher & Seater (1993) approach, it is essential to determine the order of integration of the variables. This is because the orders of integration of the variables determine the form of the LRN test. In other words, the results obtained from the Fisher-Seater approach could be spurious if the order of integration of the variables is not determined correctly.

It is quite common for macroeconomic variables to exhibit non-stationarity, which makes it necessary to test if the variables are stationary using various methods. The statistical significance level for all the tests is typically set at 5%. This means that if the p-value is less than 0.05, we can reject the null hypothesis of non-stationarity and conclude that the variable is stationary.

Once we know that the data are integrated of at least order 1, we can continue with the Fisher-Seater approach. However, it is important to note that determining the order of integration is not always straightforward. To test the order of integration, several unit root tests are present in the literature, such as the ADF test or Philips-Perron test. By using various unit root tests, we can determine the order of integration of the variables and ensure that the analysis is accurate and reliable. ADF test is based on the following autoreggressive process:

$$y_t = \mu + \rho y_{t-1} + \epsilon_t \quad (3.2.0.1)$$

where μ and ρ are parameters, and ϵ_t is white noise. The ADF test uses root unit as null hypothesis, $H_0 : \rho = 1$ and $H_1 : \rho < 1$.

Fisher and Seater define several possible scenarios that depend on the order of integration of the variables:

1. When $k < 1$, there are no permanent shocks to the level of the money stock, thus the long run derivative is not defined.

2. If $k \geq l + 1 \geq 1$ then there are permanent shocks to the level of the money stock, but no permanent shocks to the level of the real output. Thus, long-run derivative is zero ($LRD_{y,m} = 0$) and long-run neutrality is violated if y is a nominal variable, otherwise it holds (Bullard 1999).

3. $k = l \geq 1$. In this scenario, we can test for long-run neutrality in order to find out if the permanent shocks to the level of money stock are correlated with the permanent shocks to the real output.

When it comes to super-neutrality, Fisher & Seater (1993) suggest that money is long-run superneutral with respect to y when $LRD_{y,\Delta m} = 0$. The cases are:

1. When $\Delta k < 1$ there are no permanent shocks to the growth rate of the money stock. Therefore, the data are inconclusive regarding monetary super-neutrality.

2. If $\Delta k \geq l + 1 \geq 1$ then the growth rate of money has been a subject to permanent shocks. However, this does not apply to l. Long-run derivative is zero and superneutrality holds.

3. $\Delta k = l \geq 1$. When this situation occurs, we can test for long-run super-neutrality to find out whether permanent shocks to the level of the money stock are correlated with the permanent shocks to the real output.

4. $\Delta k = l - 1 \geq 1$. One way to tell if a lasting change in the money growth rate is linked to a lasting change in the growth rate of the economy is by examining the two together.

We can see a clear distinction between neutrality and superneutrality. As Bullard (1999) pointed out, narrower monetary aggregates tends to be integrated of order 1, while broader aggregates tends to be integrated of order two. If money is integrated of order two then superneutrality can be tested whereas neutrality cannot. However, in some cases, Weber (1994) conducts neutrality tests with caution despite this.

Chapter 4

Data Description

4.1 Money Supply and Monetary Aggregates

4.1.1 The Money Supply

The amount of money accessible in an economy is called the money supply (Puah et al. 2008). Monetarists regard the money supply as crucial in understanding economic dynamics (Puah et al. 2008). The money supply within a country is predominantly influenced by its central bank. To raise the overall money in circulation, the central bank purchases financial assets from the public via open-market purchases which leads to an overall increase in public money holdings and a rise in the overall money in circulation (Puah et al. 2008).

On the other hand, to diminish the money supply, the central bank may sell financial assets to the public in exchange for currency. Another way how the central bank can manipulate the money supply is by changes in reserve requirements. The central bank establishes the minimum reserve requirement that banks must maintain for each type of deposit (Puah et al. 2008). When banks are compelled to hold more reserves, the reserve-deposit ratio is increased which leads to a reduction in the money supply.

Another tool that influences the money supply is discount window lending. Discount window lending refers to the central bank's practice of providing reserves to banks. When the discount rate increases, borrowing from the discount window becomes more expensive for banks. Consequently, banks tend to decrease their borrowing, leading to a decrease in the monetary base.

4.1.2 Monetary Aggregates

The concept of money is one of the most fundamental ideas in economics. It is used to facilitate transactions and exchange goods and services in an economy. However, it is challenging to find a single comprehensive measure of the money stock in an economy. As a result, economists rely on multiple measures, known as monetary aggregates (Puah et al. 2008).

Monetary aggregates vary in their definition of money and represent different levels of liquidity in an economy. The two most commonly used aggregates are narrow money (M1) and broad money (M2). M1 is the sum of banknotes and coins in circulation and overnight deposits. It is typically used as the main measure of transactions in an economy. M1 is highly liquid and can be used immediately to buy goods and services.

M2 includes M1 plus savings deposits and small-time deposits (Puah et al. 2008). Savings deposits are accounts where individuals can store money for future use, and small-time deposits are accounts where individuals can deposit money for a fixed period and receive interest. M2 is a broader measure of money than M1 and includes assets that can be converted into cash relatively quickly.

M3 consists of M2 and large-time deposits, which are accounts where individuals can deposit money for a longer period and receive higher interest rates. M3 is the broadest measure of money and includes assets that are less liquid than M2.

In conclusion, monetary aggregates are essential tools for economists to analyze and understand the money supply in an economy. Each aggregate represents a different level of liquidity and helps economists track the movement of money within an economy. While M1 is the most commonly used aggregate, M2 and M3 provide a more comprehensive view of the money supply and are useful in understanding the behavior of financial markets.

Table 4.1: Monetary Aggregates

Monetary Aggregate	**Definition**
M0	Cash in Circulation
M1	M0 + Checkable Deposits
M2	M1 + Savings Deposits
M3	M2 + Large Time Deposits

4.2 Data

The objective of this thesis is to investigate long-run neutrality, a hypothesis concerning the effects of money on real output. The definitions of money supply used are M1, M2, and M3. It is important to understand the critical role played by these monetary aggregates in shaping the dynamics of the economy and their implications for real economic activity over time. Real output is represented by GDP.

In contrast to the prevailing trend in research that predominantly relies on annual data to evaluate money neutrality, this thesis has deliberately chosen to employ quarterly data spanning from 1996 to 2023. This strategic decision was reached as a result of the inadequacies inherent in annual data for robust econometric analysis within the specific context of this study. The sample size obtained from annual data, consisting of only 27 observations, proved to be insufficient to maintain valid confidence intervals, and the use of annual data with extended lag values resulted in an unacceptable reduction in the number of variables in the regression, thereby yielding unreliable results. On the contrary, the adoption of quarterly data has significantly expanded our observations to over 100, thereby yielding a more comprehensive dataset for analysis. This strategic approach has not only offered a more relevant and insightful horizon for policy analysis but has also ensured that the statistical significance and reliability of the results are maintained. Therefore, this methodological adjustment aligns more effectively with the best practices in econometrics, ultimately enhancing the robustness and validity of our findings. The quarterly time series data is extracted from the database of the National Bank of Slovakia. The graphs of the variables are presented below, the series being in their natural logarithm.

Figure 4.1 illustrates the logarithmic transformation of Slovakia's GDP on a quarterly basis. The time series data reveal a steady upward trend, indicating consistent economic growth over the period. Early in the series, there is a noticeable but moderate increase. The growth rate appears to accelerate in the mid-2000s, likely influenced by Slovakia's accession to the European Union in 2004, which provided an integration into the European market. The graph also shows minor fluctuations, such as a dip around the 2008-2009 period, corresponding to the global financial crisis, which temporarily hindered economic growth. Despite this setback, the GDP quickly rebounded, continuing its upward trajectory. Another minor dip is observed around 2020, likely attributed to the economic impact of the COVID-19 pandemic. Despite these disruptions,

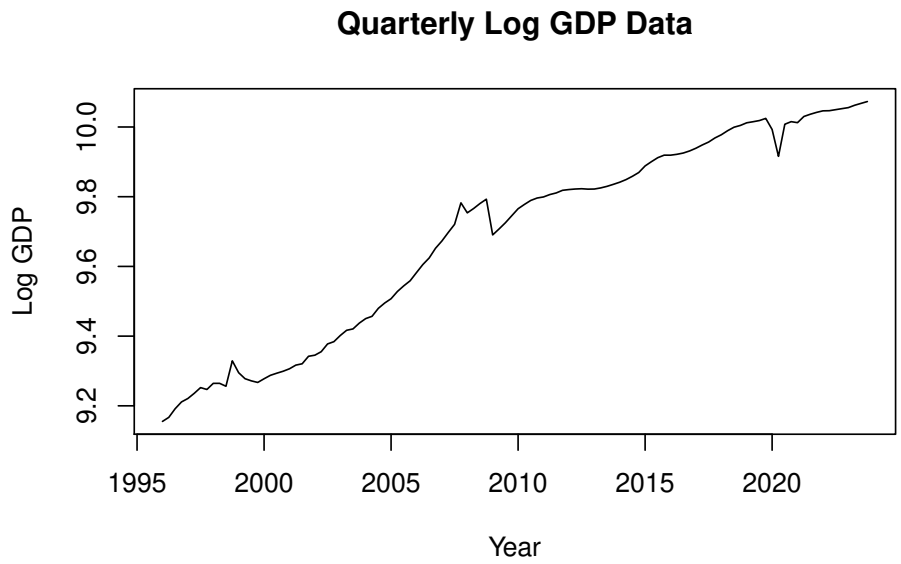


Figure 4.1: Log of GDP

the overall trend remains positive.

Figures 4.2, 4.3, and 4.4 provide the logarithmic transformations of Slovakia's money supply represented by monetary aggregates M1, M2, and M3. M1 includes the most liquid components of the money supply. The time series shows a clear and consistent upward trend, indicative of a growing monetary base over this period. The growth in M1 became more pronounced in the mid-2000s. The graph shows some fluctuations, particularly around the global financial crisis. Broader monetary aggregates, M2 and M3, reveal a similar upward trend. Integration into the European financial system likely enhanced monetary stability and increased investment inflows. While minor fluctuations are observable, the growth rate appears to stabilize shortly thereafter.

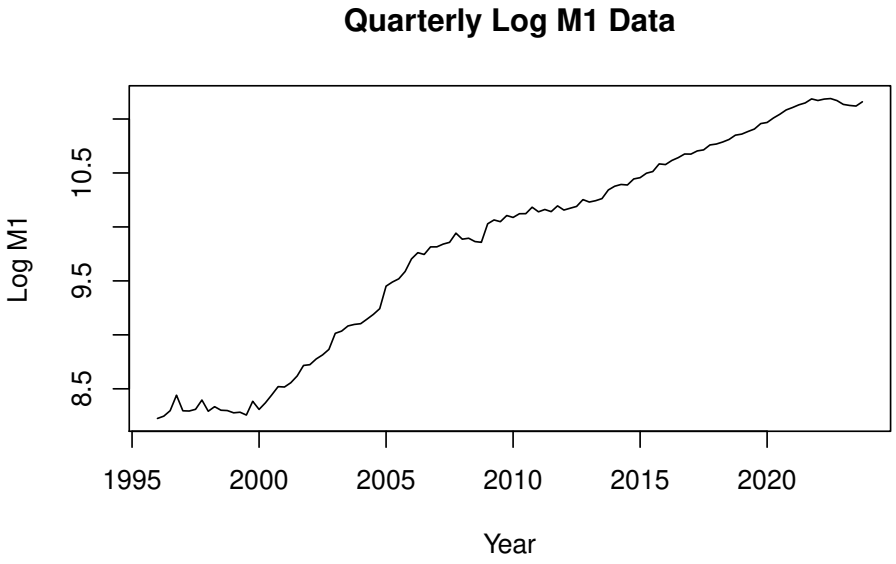


Figure 4.2: Log of M1

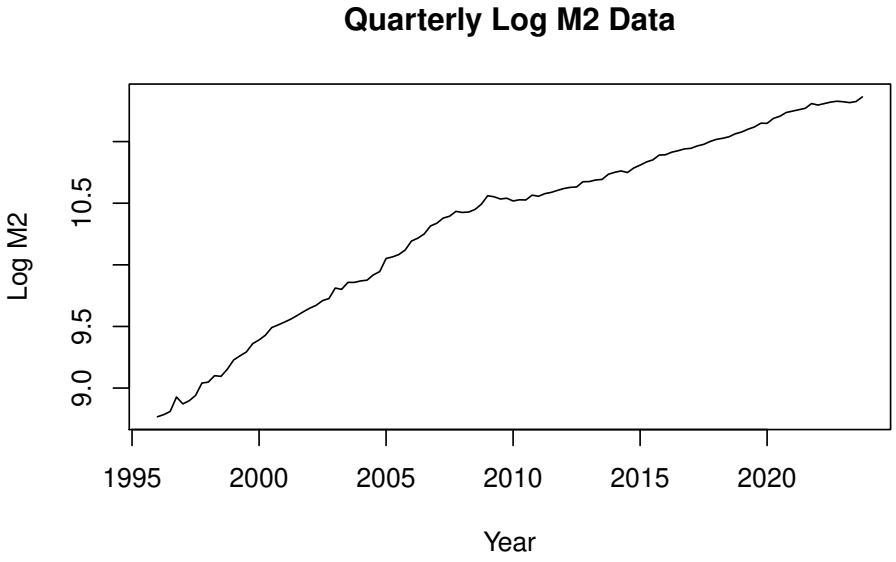


Figure 4.3: Log of M2

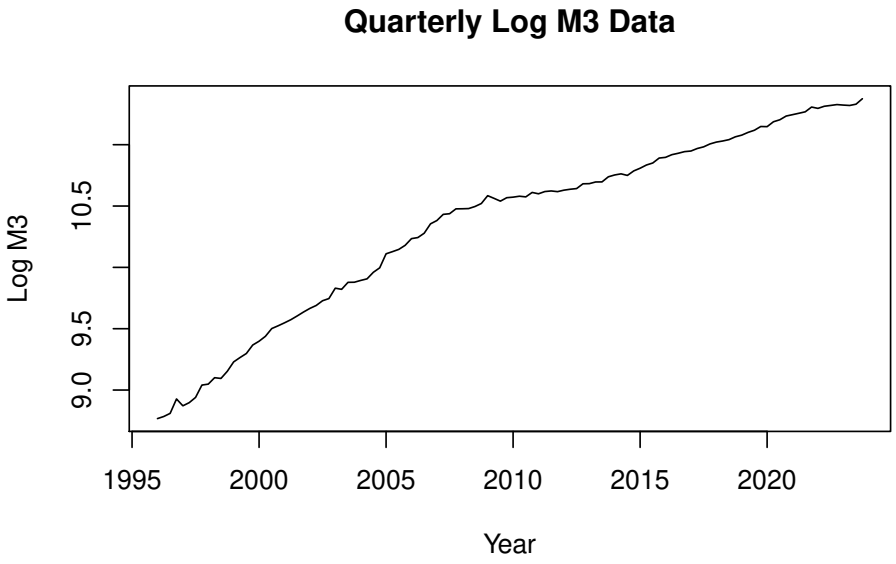


Figure 4.4: Log of M3

Chapter 5

Results and discussion

This chapter provides an overview of derived estimates, statistics, test results, and other findings.

5.1 Unit Root Tests

As mentioned in the previous chapters, the implementation of the FS methodology to test the long-run neutrality of money using money supply represented by M1, M2, and M3 towards output represented by real GDP can only be done if both the money variable and the output variable are similarly integrated or I(1). Therefore, it is imperative to determine the order of integration of a time series before conducting any further analysis. A stationary series suggests temporary shocks, preventing us from testing the neutrality proposition. Additionally, second order of integration implies permanent shocks to the growth rate of the series. In this scenario, we can test for superneutrality but not for neutrality.

To investigate whether the variables are stationary, the ADF test is performed. The ADF test is a statistical hypothesis test widely used to determine whether a unit root is present in an autoregressive model. If a unit root is present, the time series is non-stationary and tends to follow a random walk. On the other hand, if the null hypothesis of a unit root is rejected, it implies that the time series is stationary and has a finite mean and variance.

The table 5.1 contains the results of the stationarity tests for the variables under consideration. To determine the stationarity of the series based on the results of the ADF test for the logarithmic variables, we need to assess the p-values. If the p-value is less than the chosen significance level (usually 0.05),

we can reject the null hypothesis of a unit root and conclude that the series is stationary. Upon reviewing the table 5.1 it becomes apparent that none of the p-values associated with the ADF test results for the logarithmic variables are less than 0.05. As a result, we fail to reject the null hypothesis of a unit root for any of the variables. This suggests that none of the logarithmic variables are stationary at the chosen significance level.

Table 5.1: Result of Variables Unit Roots Test in Model

Variable	**ADF**	**p-value**	**Variable**	**ADF**	**p-value**
GDP	-1.2748	0.8775	Δ GDP	-4.6955	0.01
M1	-1.2961	0.8687	Δ M1	-3.382	0.06111
M2	-2.229	0.4816	Δ M2	-4.4495	0.01
M3	-2.3315	0.439	Δ M3	-4.1605	0.01

The results of the ADF tests on the first differences of the series suggest that GDP, M2, and M3 exhibit stationarity, indicating integration of order one. Consequently, we may proceed with the neutrality tests for these variables. However, the first difference of M1 does not demonstrate stationarity but achieves it after a second differencing, implying integration with order two. Results can be observed in table 5.2. This signifies the presence of shocks to the growth rate of the series. Thus, superneutrality can be tested, while neutrality cannot. In this context, we will follow the approach outlined by Weber (1994) and conduct neutrality tests cautiously, particularly for M1.

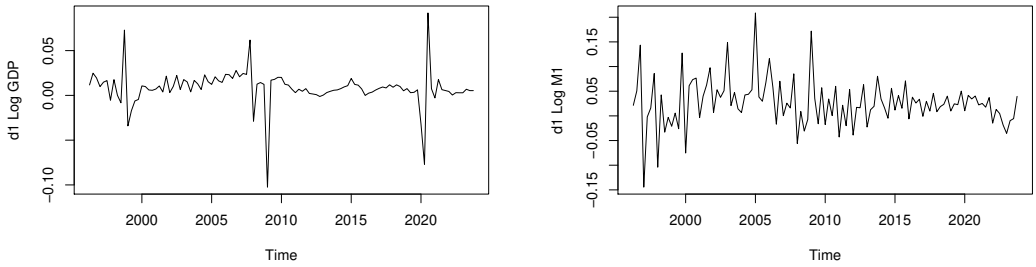
Table 5.2: Results for M1

Differencing	Test Statistic	Lag Order	p-value	Alternative Hypothesis
First Differencing	-3.382	4	0.06111	Stationary
Second Differencing	-8.4217	4	0.01	Stationary

The following table 5.3 summarizes the integration order for each variable of interest.

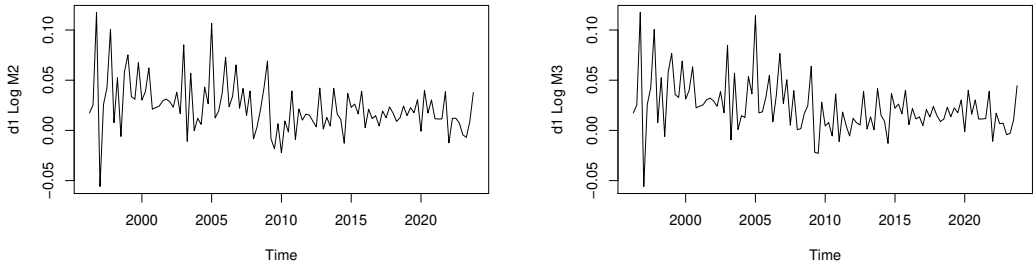
Table 5.3: Order of Integration for Variables

Variable	**Order of Integration**	**Variable**	**Order of Integration**
GDP	I(1)	M2	I(1)
M1	I(2)	M3	I(1)



(a) Log of ΔGDP (b) Log of ΔM1

Figure 5.1: First Differences, GDP and M1



(a) Log of ΔM2 (b) Log of ΔM3

Figure 5.2: First Differences, M2 and M3

5.2 Long-Run Money Neutrality Test for M1

The result of the money neutrality test of M1 using FS methodology based on equation 3.1.0.5 is shown in figure 5.3. The provided graph plots the coefficient estimates for various lags (j) with the vertical axis representing the coefficient estimates and the horizontal axis representing the lag j ranging from zero to eighty. By limiting the horizon to a maximum of eighty lags we ensure that the regression results are based on a sufficient number of observations, enhancing the reliability of the coefficient estimates. The black dots represent the coefficient estimates at each lag, while the dashed lines denote the upper and lower bounds of the confidence intervals. The horizontal line at zero indicates no effect. Each coefficient, b_j, represents the estimated response of the change in log real GDP to the change in logged money. Quantitatively speaking, the point estimates of b_j for the range of lags from $j = 10$ to $j = 60$ are roughly between 0.2 and 0.3. This suggests that a permanent 1% increase in M1 per quarter would lead to a long-term increase in real GDP of about 0.2% to 0.3%.

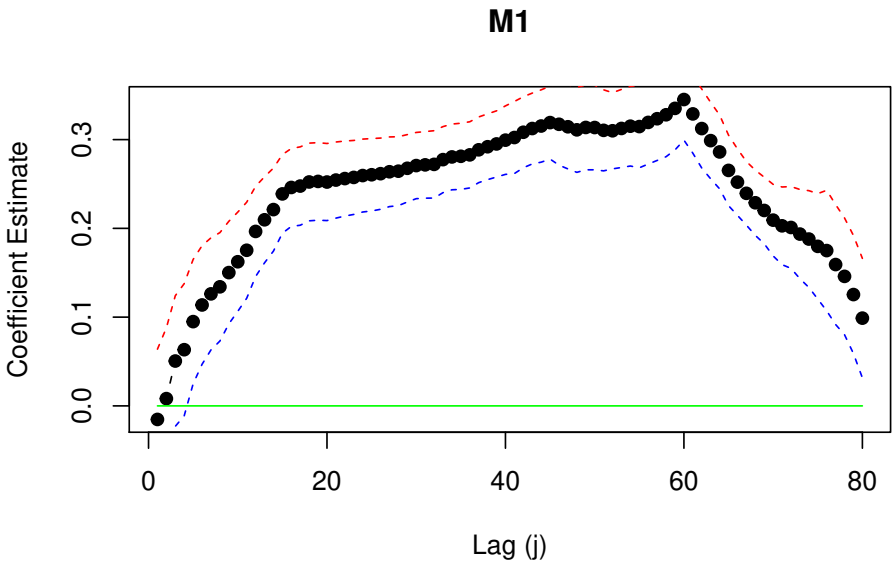


Figure 5.3: Money Neutrality Test for M1

5.2.1 Peak and Decline

Initially, at lower lags, the coefficient estimates rise from zero to about 0.1. This indicates a growing but moderate positive relationship between M1 and GDP in the short term. The coefficient estimates reach their peak around $j = 60$, with a value exceeding 0.3. This suggests a strong positive relationship between M1 and GDP. After this peak, the estimates start to decline, indicating a tapering effect of M1 on GDP.

5.2.2 Statistical Significance

The confidence intervals (dashed lines) do not encompass the horizontal line for a significant portion of the lag range. This indicates that the coefficient estimates are statistically significant.

5.2.3 M1 is Not Neutral

As the figures 5.3 show, all the estimated b_j are positive and statistically significant, ranging from 0.1 to 0.35. For Slovakia, M1 is not neutral over this period according to our analysis. However, as we stated previously, M1 is integrated of order two, and the real output is integrated of order one. In the FS framework, this unequivocally suggests that money is long-run neutral (Fisher

& Seater 1993), contradicting our findings. Furthermore, it indicates that while superneutrality can be tested, neutrality cannot. We conducted the neutrality test despite this fact, following Weber (1994). Therefore, we need to interpret our results with caution. Nevertheless, our findings align confidently with those reported by Škare et al. (2016).

5.3 Long-Run Money Superneutrality Test for M1

M1 is the only monetary aggregate in our analysis suitable for testing money superneutrality as it is integrated of order two. The result of the money superneutrality test is shown in figure 5.4. The coefficient estimates range from approximately -0.3 to 0.3. Initially, the coefficients are negative and gradually increase, crossing zero around $j = 50$. They peak at around 0.3 at approximately $j = 70$. The confidence intervals are wide, indicating significant variability in the estimates.

5.3.1 Statistical Significance

Upper and lower bounds (dashed lines in figure 5.4) often encompass zero, indicating periods where the coefficients are not statistically significant. There are a few coefficient estimates that do not follow this pattern and display a statistically significant relationship between the growth rate of M1 and GDP. Nonetheless, the broader analysis suggests that the confidence intervals generally include zero, thereby providing support for the superneutrality hypothesis.

5.3.2 M1 is Superneutral

The empirical results indicate that M1 is superneutral in Slovakia given the vast majority of periods where the coefficients are not statistically significant. Thus, the overall conclusion leans towards an acceptance of superneutrality hypothesis. The outcome of the long-run superneutrality test is not affected in any way by the conclusion shown in FS framework regarding the long-run neutrality of M1 arising from its order of integration.

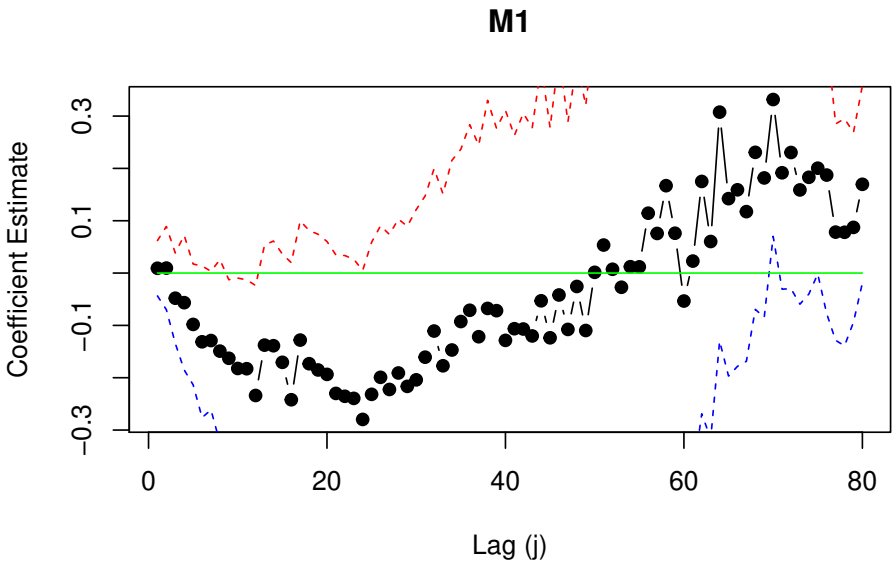


Figure 5.4: Money Superneutrality Test for M1

5.4 Long-Run Money Neutrality Test for M2

The values of b_j for logged M2 and the confidence intervals are plotted in figure 5.5.

5.4.1 Peak and Decline

The coefficient estimates start close to zero and increase significantly as the lag increases. At very early lags, the coefficient estimates are near zero, implying minimal immediate impact of M2 changes on real GDP. The coefficient estimates continue to increase until about $j = 30$, reaching a peak slightly above 0.3. This indicates a strong positive effect of changes in M2 on real GDP during this period. From $j = 30$ to $j = 50$, the coefficients stabilize and begin a slight decline, suggesting that while the effect of M2 changes is strong, it starts to diminish slightly after reaching the peak. At the later lags, the coefficient estimates decrease gradually but remain significantly positive. This indicates a lingering but reduced impact of M2 changes on real GDP.

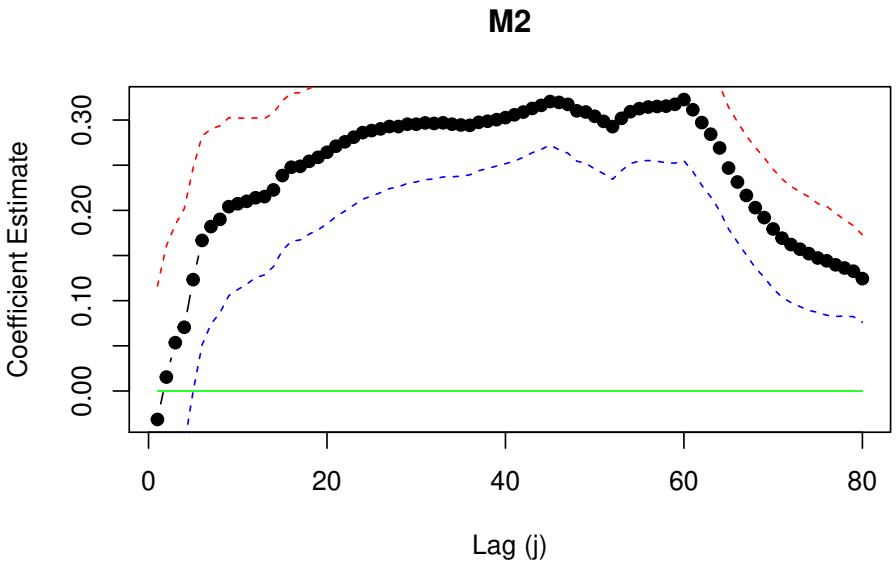


Figure 5.5: Money Neutrality Test for M2

5.4.2 Statistical Significance

The confidence intervals do not encompass zero for most of the lags, suggesting statistical significance.

5.4.3 M2 is Not Neutral

As the figures 5.5 show, all the estimated b_j are positive and statistically significant. The analysis confirms that M2 is not neutral.

5.5 Long-Run Money Neutrality Test for M3

Upon analyzing the data, the figure 5.6 clearly show that the coefficients of M3 exhibit a striking similarity to those of M2. Initially, they display an upward trend and then stabilize, mirroring the pattern observed in M2. Furthermore, the confidence intervals for M3 also follow a similar trajectory as those in M2. It is noteworthy that the coefficients are found to be statistically significant for most lags, indicating a discernible impact on real GDP. This implies that akin to M2, M3 does not demonstrate neutrality, as the b_j terms are both positive and statistically significant for all values of j.

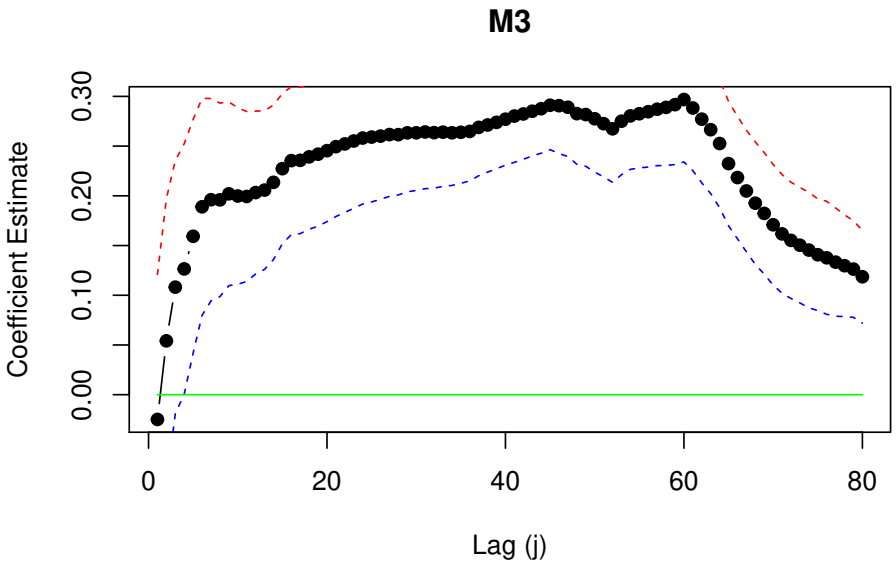


Figure 5.6: Money Neutrality Test for M3

5.6 Policy Implications

Liquidity is crucial for financial transactions, but its absence can hamper a country's economic progress. Conversely, an excessive increase in cash flow can lead to inflation (Iranmanesh & Jalaee 2021). Managing cash flow in line with production growth is a primary responsibility of monetary policy. By employing this approach, a country's monetary authorities can regulate the circulation of money in the economy and influence economic progress by directing it toward productive investments. Economists and researchers have consistently examined the impact of changes in the volume and growth rate of money on production, reflecting a continuous interest in the effectiveness of liquidity and currency (Iranmanesh & Jalaee 2021). It's crucial to carefully consider the best policies and tools to ensure stability which is why it's important to thoroughly assess the neutrality of money in each country's economy, considering the costs associated with implementing monetary policies.

The findings of our money neutrality testing have several policy implications for monetary authorities. Our analysis revealed that changes in the stock of money do have long-run real effects. Contrary to neutrality propositions, money matters in the long-run in Slovakia regardless of the measure of monetary aggregate. Thus, we can consider monetary policy as an efficient tool when it comes to controlling inflation, creating a proper condition to increase

production and employment to the potential level, and preserving the value of the national currency. The significant and positive relationship between any measure of money and real GDP suggests that expanding the money supply can stimulate economic growth. In an inflation-targeting framework, monetary authorities should not neglect the importance of money supply towards the long-run increase of output. Real economic activity can be governed through monetary policy.

Nevertheless, it's important to consider the policy implications of our money neutrality testing in Slovakia in light of the limitations in our analysis. One key limitation is the relatively short time series we used for long-run testing, which may raise questions about the accuracy of unit root tests. Moving forward, it is essential for future research to address these concerns by leveraging more comprehensive data sources and longer time series. Doing so will lead to a more robust understanding of the dynamics of money neutrality and its implications for economic policy. Another limitation in our analysis is that since January 2009, Slovakia has relinquished its autonomy in monetary policy. It now operates under the influence of the Euro area policy, thereby potentially diminishing the relevance of the policy implications outlined in this thesis. However, despite Slovakia being part of the Eurozone and not having its autonomous monetary policy, the results of our neutrality testing are still of significant interest. Understanding the relationship between money supply and GDP in Slovakia contributes to a broader understanding of monetary policy effects within the entire Eurozone, providing context for similar economies. The results of neutrality tests provide insights into the specific dynamics of Slovakia within the Eurozone, highlighting whether Slovakia experiences different effects compared to other member states where similar money neutrality tests have been conducted. Nevertheless, investors operating in Slovakia can use these findings to better understand the macroeconomic environment, potentially adjusting their strategies.

Chapter 6

Conclusion

Extensive theoretical discussions and a diverse array of empirical research have been made regarding the concept of money neutrality, a fundamental tenet in monetary economics that posits that in the long-run, the money supply is neutral and changes in the money stock affect only nominal variables, leaving the real variables unchanged. This thesis set out to empirically test the validity of the long-run money neutrality hypothesis in Slovakia using the FS methodology applied to quarterly time series data. The implementation of the FS methodology requires that both the money supply and output variables be integrated of the same order, I(1). A diagnostic ADF test for unit-root was conducted, which confirmed that the test for long-run money neutrality applies to Slovak data for the period from 1996 to 2023. Our analysis focused on monetary aggregates M1, M2, and M3, with output represented by real GDP. Among these aggregates, M1 was identified as the only one suitable for testing money superneutrality as it is integrated of order two. Thus, we can test for superneutrality and not for neutrality in this setting, but there are some exceptions in the literature where neutrality tests are conducted anyway (Bullard 1999). Our empirical findings suggest that changes in the stock of money do indeed have long-run real effects in Slovakia, indicating that money is not neutral. Furthermore, our results reveal that when M1 is the criterion, the superneutrality of money cannot be rejected.

These findings have several significant policy implications. They suggest that monetary policy can be an effective tool for maintaining economic stability. Despite Slovakia's lack of autonomous monetary policy since its integration into the Eurozone in 2009, the results of our analysis provide valuable insights into how a small, open economy operates within a larger monetary union con-

dition. Given these results, policymakers in Slovakia and similar economies within the Eurozone might consider the implications of monetary interventions on real economic variables. The observed non-neutrality of money implies that changes in the money supply can have substantial long-term impacts on real output. Therefore, monetary authorities should carefully consider the timing and magnitude of policy measures to achieve desired economic outcomes without triggering unintended consequences.

It's important to consider the policy implications of our money neutrality testing in Slovakia in light of the limitations in our analysis. This thesis is limited by the relatively short time series data we used for long-run testing. It is suggested to repeat the estimations in the future when the data period is satisfactory. Furthermore, other possible estimation methods can be tried to propose a more complex and advanced approach. Future research could also investigate the effects of money supply changes on price levels to understand inflation dynamics in response to monetary policy. Analyzing the differences in monetary neutrality across the full sample, as well as before and after Slovakia enters into the Eurozone, could provide nuanced insights. Special attention should be given to the period of the Exchange Rate Mechanism II, while it might be intuitive to group this period with the Eurozone membership phase, a thorough analysis considering both groupings could yield more accurate results. Furthermore, in future research, it might be beneficial to capture the dynamic effects of monetary policy using an Autoregressive Distributed Lag model for money supply and output. By incorporating these additional analyses, future research can provide a more comprehensive understanding of the intricate effects of monetary policy and contribute valuable insights for both academic discourse and practical policymaking.

In conclusion, this thesis contributes to the ongoing discourse on money neutrality by providing empirical evidence from Slovakia, highlighting the non-neutrality of money in the long-run.

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