Interactions amongst macro-economic variables: New global evidences

Dr. Ahmad AlHarbi[1], Prof. (Dr.) Moid U Ahmad[2], Dr. Mona Mohamed Aly Elshaabany[3]
[1]Alasala College, Kingdom of Saudi Arabia, atalharbi@yahoo.com.au
[2]Lead Researcher, Scholeio Education and Evolving Knowledge, Lucknow, India scholeio.learn@gmail.com
[3]Assistant Professor, College of Business, Jouf University, Kingdom of Saudi Arabia. mmelshabany@ju.edu.sa

Abstract: *Monetary and economic policy of a country considers different macroeconomic variables for an effective and desirable economic growth. The paper is aimed to understand the inter variable impact of five macroeconomic variables across a sample of 63 countries. The research is based on a panel data for the period 2000-2023(annual data) and applies the panel data technique along with causality analysis to understand and assess the relevant macroeconomic dynamics. Apart from descriptive analysis, correlation and regression analysis is also done to draw conclusions. A bidirectional relationship is observed between GDP, Money supply and exchange rates, which is validated by correlation analysis, causality analysis and VAR results.*
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1. INTRODUCTION:

The monetary policy of an economy reviews the macroeconomic variables with a larger objective of contribution to the national economic growth (Ahmad & Nasrin,2017). Researchers have discussed the role of economic growth [Karahan (2020)], money supply [Ahmed et al.(2011)],inflation[Ascari et al.(2024); Eleftheriou & Kouretas (2023)],interest rates [Ahmad & Al-Deehani(2023); Ahmad & Premaratne(2020); Bauer & Rudebusch (2020)] and exchange rates [Karahan (2020)] in the context of implications of the monetary policy.

The money supply plays a critical role in controlling inflation, supporting economic growth, influencing interest rates, and maintaining the overall stability of the economy. Proper management of the money supply is central to achieving macroeconomic goals like price stability, low unemployment, and sustainable growth. Inflation plays a critical role in shaping an economy's overall health. Moderate inflation is generally seen as a sign of economic growth, whereas high or volatile inflation can have negative consequences, including eroding purchasing power, disrupting savings, raising costs for consumers and businesses, and making economic planning more difficult. Interest rates are a key driver of economic activity and have far-reaching effects on consumers, businesses, government policies, and financial markets. Fluctuations in exchange rates can have a direct impact on a country's competitiveness, its ability to manage inflation, the cost of debt, and the welfare of its citizens. Therefore, both businesses and governments closely monitor exchange rates to make informed decisions about trade, investment, and economic policy.

Interest rates play a pivotal role in influencing economic growth by shaping borrowing costs, investment decisions, consumer spending, savings behaviour, financial market dynamics, and international capital flows (see Nasir et al.,2014). Ahmad & Al-Deehani (2023) observed that debt of a country can be explained by savings rate and the GDP growth rate. McKinnon (1973) argues that lending rate leads to financial development and hence to economic growth. Interest rates play a pivotal role in influencing economic growth by shaping borrowing costs, investment decisions, consumer spending, savings behaviour, financial market dynamics, and international capital flows (see Nasir et al.,2014). Milton Friedman (See Friedman,1966) emphasized the importance of stable and predictable interest rates as a key determinant of economic stability and growth. As per the Keynesian economics (Gordon,1990) it is argued that interest rates, along with expectations about future returns and uncertainty, affect investment

decisions and consumer spending. Interest rates impact international capital flows and exchange rates (see Karahan,2020).

Keynesian economics also focuses on the role of aggregate demand in driving economic growth. Adam Smith (1776) emphasized the role of specialization and division of labour in promoting economic growth. Friedman (1966) argued that long-term economic growth is primarily determined by monetary factors, such as the growth rate of money supply. John Maynard Keynes (see Gordon,1990) challenged the classical view that savings automatically lead to investment and economic growth. Keynes argued that saving alone does not guarantee economic expansion if aggregate demand is insufficient. Robert Solow's growth theory (see Solow1994), highlighted the role of savings in promoting economic growth through capital accumulation and productivity improvements. Thomas Piketty (see Yun,2022) argued that policies affecting savings rates and wealth taxation can have profound implications for economic inequality and social cohesion.

The relationship between money supply and GDP (Gross Domestic Product) is a crucial aspect of monetary economics. Changes in money supply can influence interest rates, which affect consumption and investment decisions, thereby impacting aggregate demand and GDP. Alterations in money supply can also affect credit availability and borrowing costs, influencing business investment and consumer spending, which in turn affect GDP growth. Changes in money supply can impact exchange rates, affecting exports and imports, which are components of GDP in an open economy context. Central banks may adjust money supply growth targets to support GDP growth objectives, aiming to stimulate economic activity during downturns or to control inflation during periods of high growth. Effective management of money supply is essential for stabilizing the economy, reducing volatility in GDP growth rates, and promoting sustainable economic expansion over the long term. The role of money supply in economic growth is significant, as it influences various aspects of an economy's performance, including consumption, investment, employment, and overall economic activity.

Foreign exchange rates are a type of commodity which has a usage in almost all sectors of an economy [Wong (2013); Karahan (2020)]. Foreign exchange market includes traders, investors, speculators and arbitrageurs operating at individual and institutional level. A central bank adopts a monetary strategy to affect various macroeconomic parameters such as inflation, exchange rate and economic growth (Ahmad & Premaratne,2020). Kasem & Al-Gasaymeh (2022) found that there exists a cointegrating relationship between exchange rate, domestic and foreign price levels for the selected countries. Taylor (1995) observes that the exchange rate economics has been the most dynamic and challenging area of the last 20 years. Inflation is a major challenge for the central bank while deciding the monetary policy changes to control inflation (Eleftheriou & Kouretas,2023). Forecasting inflation is not an easy task as several techniques and numerous parameters are to be considered, local as well as international. A VAR based study was conducted by (Ahmad and Nasrin, 2017) where they found that Repo rate is one of the main monetary policies tools that influences different macroeconomic variables such as economic growth, inflation, foreign direct investments, and foreign exchange rate.

2. LITERATURE REVIEW:

Some of the economists (Amartya Sen; J. M. Keynes; Adam Smith) and their theories have shaped the discourse on economic growth by providing insights into the factors that drive it, the policies that can sustain it, and the societal implications of growth patterns. Ascari et al.,(2024) observed that an optimal monetary policy response to global-supply-induced inflation is a non-linear function of the degree of global value chain participation. Eleftheriou & Kouretas(2023) observed that unrestricted estimates reveal a stable target path for the policy rate with a strong response to inflation and an effective control over it. Ahmad & Al-Deehani (2023) observed that debt of a country can be explained by savings rate and the GDP growth rate. Fry (1980) studied 7 Asian countries with uncertain and volatile relationship between the interest rate changes and economic growth. Etale & Ayunku (2017) found a strong evidence that treasury bills and commercial papers had positive and significant influence on GDP, contrary to Ayebaemi & Francis(2018) who found that selected money market instruments (certificate of deposit and commercial paper) have an inverse relationship with the economic growth. Zhu et al.,(2022) observed that an undervalued currency enhances exports and has a significant impact on economic growth and that nexus between exchange rate and exports holds true for the Export-led Growth (ELG) and Growthled

Exports (GLE) hypotheses. Karahan (2020) observed that that there is a negative causal relationship between exchange rates and economic growth. He argues that, even under the inflation targeting regime in Turkey, both, prices and exchange rate stability should move together. Zakhidov (2024) comment that the implications of economic indicators are far-reaching, impacting businesses, investors, policymakers, and consumers alike. Panda et al.,(2023) found that the market returns positively influence exchange rates. In contrast, the market tends to react negatively to changes in consumer price inflation and foreign portfolio investment. Zeytoonejad et al., (2023) observe that the degree of openness of an economy has a negative effect on FDI inflows to agricultural sectors.

Considering the availability of literature in macroeconomics, this study is an attempt to draw inferences from a large global sample and bring forth new insights regarding the intra dynamics of monetary rates. The research is novel and imperative in the context of the sample of a panel of selected five variables used for 63 countries for a long time period (2000-2023). The inclusion of money supply as a study variable has not been commonly studied in previous researches.

3. RESEARCH METHODOLOGY:

A monetary policy is a tool to control monetary and financial parameters. Sound understanding of macroeconomic dynamics is imperative for any policy maker and economic regulator. The primary objective of the study is to draw inferences from dynamic interactions amongst, money supply, interest rates, GDP, Prices and exchange rates at a country level, globally.

The research involves working on a panel data using correlations, regressions, causality analysis and Vector Auto Regression (VAR) techniques to draw inferences. Etale & Ayunku (2017) applied Granger causality tests (see Tekin ,2012) on macroeconomic time series. Panda et al.(2023) used panel VAR on macroeconomic time series.

Subsequent to the analysis of basic statistics and panel regressions, a panel data random effect/fixed effect approach is followed to check for robustness in the relationships (see Ahmed & Suliman,2011). Zhu et al.,(2022) did a similar study using panel data to investigate the potential nexus of gross domestic product (GDP), exports and exchange rates in Asian countries over the period of 1981–2016. Karahan (2020) used Granger causality test (Granger,1987) to evaluate the relationship between foreign exchange and economic growth. Etale & Ayunku(2017) used a similar methodology in their research.

The sample includes 63 countries across the globe. These sample countries were selected on the basis of data availability for the common variables and common time period. Annual time series datasets have been used in this study. The time period of the sample data considered for the study is from the year 2000 to 2023 for five variables (GDP, Money Supply, Prices, Exchange rate, Interest rates). The five study variables are explained in table 1. The source for all data variables is International Financial Statistics at the International Monetary Fund (www.data.imf.org). Eviews 11 software is used for statistical analysis.

Table 1: Description of study variables

Sl.No.	Variable	Code	Description
1	GDP	GDP	Gross Domestic Product, Real, Domestic Currency
2	Money Supply	MONSUP	Monetary, Broad Money, Domestic Currency
3	Inflation (Prices)	PR	Consumer Prices
4	Exchange rate	EXR	National Currency per U.S. Dollar, end of period
5	Interest rates	INR	Percent per annum

4. Analysis & discussion:

The section initially interprets the descriptive statistics of panel data (see table 2) and then moves to a more detailed analysis. The highest coefficient of variation (CV) was observed for the GDP (6.54) as the panel included 63 countries from different economy levels. The lowest CV was observed for prices (0.66) implying an equilibrium in global prices.

Table 2: Panel descriptives

	EXR	GDP	INR	MONSUP	PR
Mean	460.74	1.56E+08	8.143	1.24E+08	116.85
Standard Deviation	1639.56	1.02E+09	9.61	6.73E+08	77.58

Coefficient of Variation (CV)	3.56	6.54	1.18	5.43	0.66
Number of observations	1504	1238	913	1341	1476

Table 3: Panel correlations

	EXR	GDP	INR	MONSUP
EXR	1			
GDP	0.89***	1		
INR	-0.059	-0.04	1	
MONSUP	0.86***	0.98***	-0.05	1
PR	0.027	0.032	0.14***	0.028

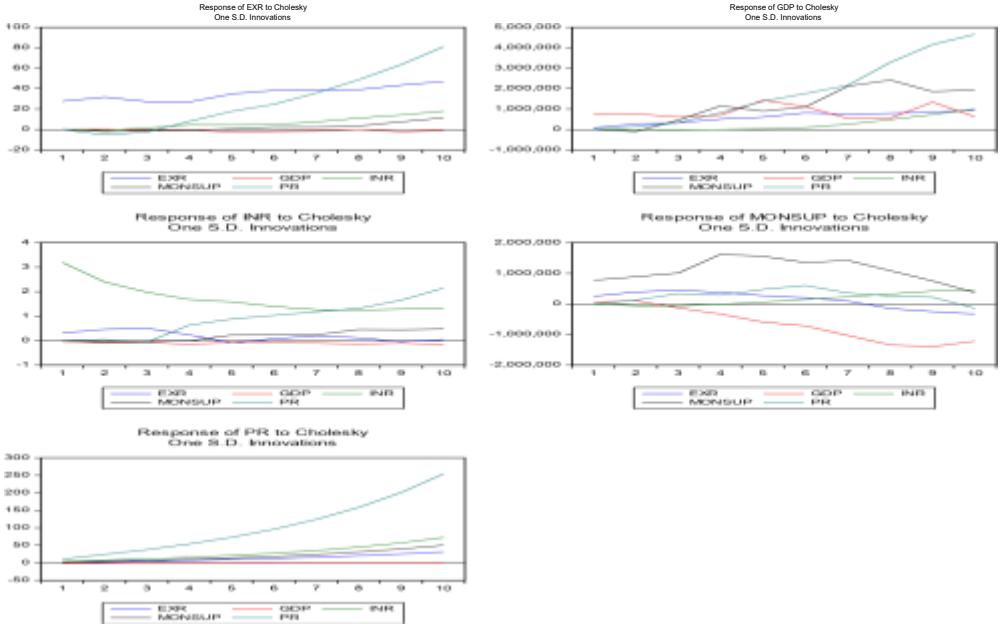
The table 3 indicates the panel correlation coefficients amongst the five study variables. A high, significant and positive correlation for GDP was observed with exchange rate (0.89) and almost a perfect positive correlation was observed with money supply (0.98). Also, a highly positive and significant correlation was observed between money supply and exchange rate (0.86). The money supply and exchange moving in the same direction with GDP implies that if GDP is improving, money supply may increase and the currency may become depreciate. This analysis is further probed in a causality analysis (see table 4). GDP and exchange rate seem to cause each other. Money supply and exchange rate also cause each other. Also, money supply and GDP cause each other. This is an interesting finding for policy makers as the money supply (controlled measure) can be applied to improve the economic growth of a country. Also, it is observed that prices cause inflation and inflation cause exchange rates implying the implication of the common economic rationale. Table 4: Pairwise Granger causality test results

Sample: 2000-2023 (Lags:5)	
Null Hypothesis:	p-values
GDP does not Granger Cause EXR	4.00E-36
EXR does not Granger Cause GDP	2.00E-30
INR does not Granger Cause EXR	0.051
EXR does not Granger Cause INR	0.87
MONSUP does not Granger Cause EXR	4.00E-49
EXR does not Granger Cause MONSUP	1.00E-32
PR does not Granger Cause EXR	0.31
EXR does not Granger Cause PR	0.95
INR does not Granger Cause GDP	0.80
GDP does not Granger Cause INR	0.95
MONSUP does not Granger Cause GDP	3.00E-37
GDP does not Granger Cause MONSUP	2.00E-45
PR does not Granger Cause GDP	0.99

GDP does not Granger Cause PR	0.98
MONSUP does not Granger Cause INR	0.99
INR does not Granger Cause MONSUP	0.76
PR does not Granger Cause INR	7.00E-16
INR does not Granger Cause PR	0.58
PR does not Granger Cause MONSUP	0.99
MONSUP does not Granger Cause PR	0.94

Post studying the intervariable dynamics at level, a Vector Auto Regression (VAR) analysis is conducted to understand the lagged impact of the variables on each other. A lag of 5 years was calculated as per the Schwarz Information Criteria. It is observed that GDP(R-squared=99.99%),exchange rate(Rsquared=99.89%),money supply (R-squared=99.99%) and prices (R-squared=98%)are best explained by the lagged values of the variables. Interest rates (R-squared=72%) is also explained well by the lagged values of the variables.

Chart 1 : The Impulse Response Function from the VAR system



The impulse response functions (chart1) indicate the shocks (impulse) of one standard deviation on the study variables over time. GDP indicated a volatile response to shocks from other variables while the prices indicated incremental shocks from other variables. Table 5: Correlated Random Effects - Hausman Test

Test Summary	Chi-Square Statistic	p-value
Period random	4.44	0.35

In panel data analysis (the analysis of data over time), the Hausman test (Hausman,1978) helps to choose between fixed effects (FE) model or a random effects (RE) model. The null hypothesis for Hausman test is that the preferred model is random effects while the alternate hypothesis is for a fixed effects model. The Hausman test to validate the significance of random effects in panel cross-sections was rejected (pvalue=0.34). Thus, a fixed effect model is applied on the variables for further analysis. The FE analysis indicated a R-squared of 97% (p-value=0) for GDP by other four variables. Similarly, exchange rate (Rsquared =80%, p-value=0), interest rate (R-squared =17%, p-value=0), money supply (R-squared =97%, pvalue=0) and prices (R-squared =43%, p-value=0) were explained by other variables, respectively.

The values of coefficient of variation implies that for the panel of countries and for the time period (2000-2023), the GDP has been most volatile (6.54) while the prices have been least volatile (CV=0.66). This highlights the inherent volatility in the economic growth and money supply (CV=5.43) across the globe (see Ahmed & Suliman,2011). Panel correlations indicate that GDP, exchange rate and money supply move in the same direction implying their significance to each other. This is further confirmed by causality analysis also (see table 4).

The fixed effects analysis indicated a significant and high R-squared values for all variables except the prices, implying the importance of the variables in monetary policy. The prices reported a low R-squared value also amongst all the variables implying that apart from GDP, exchange rates, money supply and interest rates, there are other monetary variables which may have a greater influence on the price level in an economy.

5. CONCLUSION:

The paper aimed to understand the macroeconomic dynamics amongst the selected study variables (GDP; Interest rates; Prices; Exchange rate and money supply). On the basis of observations from the findings from descriptive analysis and different regression analysis, the study successfully drew inferences to contribute to the existing literature. It is concluded that management of the selected macroeconomic variables is imperative to a stable monetary policy and national economy. A bidirectional relationship is observed between GDP, Money supply and exchange rates, which is validated by correlation analysis, causality analysis and VAR results. The results provide an understanding of the selected macroeconomic variables for better decision making and business management.

Although the sample size is large (63 countries), still it is far from a census study and thus the findings may include some sampling bias.

Future research scope: The analysis highlights certain imperative findings which enables effective monetary policy implementation at a country level. The lowest CV was observed for prices (0.66) implying an equilibrium in global prices. The inflation levels and prices can be studied further to understand the price across countries. Future studies can focus on any one variable and explore further in depth. The unidirectional causality from the money supply to the GDP should be probed in further studies for an improved macro-economic policy formulation.

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