THE IMPACT OF POLICY UNCERTAINTY ON CENTRAL BANK RESERVES: THE EXAMPLE OF THE FRAGILE FIVE

Asst. Prof. Erhan AKARDENİZ (Ph.D.) * iD

ABSTRACT

In recent years, the global economic outlook has been shaped by increasing geopolitical risks, financial vulnerabilities, and policy uncertainties. The Fragile Five countries, consisting of Türkiye, Brazil, India, Indonesia, and South Africa are more affected by these uncertainties due to their dependence on external financing. The study examines the relationship between economic policy uncertainty and international reserve adequacy during the 2005-2025 period using the panel data method. CIPS and CADF unit root tests were used along with CCEMG and AMG estimators, and the Driscoll-Kraay and Dumitrescu-Hurlin panel causality tests were also utilized. The findings indicate a positive and significant long-term relationship between policy uncertainty and reserve accumulation. Causality results support a one-way relationship from uncertainty to reserve accumulation. It is observed that Türkiye and South Africa's reserve levels are inadequate, while those of other countries are relatively strong. Türkiye and South Africa should implement policies that will elevate their reserves to a level that can serve as a buffer. The study contributes to the literature by examining the relationship between policy uncertainty and reserve adequacy in the Fragile Five countries, considering both long-term and causality dimensions.

Keywords: *Macroeconomic Uncertainty, Monetary Policy, Reserve Management, Financial Stability.*

JEL Codes: *E44, E52, F31, G15.*

1. INTRODUCTION

The global economy is going through a time right now when geopolitical risks, financial weaknesses, and policy uncertainties are all getting worse. Changes in global liquidity, capital flows, and exchange rates have a big effect on economies that are still developing. So, when the risk goes up, the central banks of developing countries change how they build up their international reserves to make sure they have enough money to deal with shocks from outside the country (Obstfeld, Shambaugh and Taylor, 2010). Central banks used to use foreign exchange reserves as a kind of "insurance" against shocks to the balance of payments and capital outflows (Aizenman and Lee, 2007). However, in recent

* Gaziantep University Social Sciences Vocational School, Banking and Insurance Department, E-mail: erhanakardeniz@gantep.edu.tr

295

Araştırma Makalesi/Research Article

years, as the risks and uncertainties of reserve accumulation policies have increased, it has been proposed that this may be closely associated with not only economic factors but also uncertainties regarding economic policy. When politics are very uncertain, investors see more risk, money leaves the country faster, and exchange rates go up. To keep the exchange rate stable or to keep people's faith in the economy, central banks change their reserve positions (Aizenman and Ito, 2022). Economic policy uncertainty (EPU) is a major way to measure how hard it is to predict economic policies. The Economic Policy Uncertainty Index was made by Baker, Bloom, and Davis (2016). It shows how unclear government policies about money, taxes, and rules affect economic choices. It's important to remember that uncertainty about economic policy only comes from government actions and announcements. This is different from broader macroeconomic uncertainty, which can come from changes in the business cycle, shocks from outside the economy, or changes in the financial markets.

In this study, the EPU index only looks at how uncertain economic policy is. We also take into account general macroeconomic uncertainty by looking at things like inflation, growth, interest rates, and exchange rates.

When the EPU is high, businesses in developing countries make decisions that affect the market and cause money to leave the country. This situation has a direct effect on how central banks choose to build up and keep reserves (Beckmann and Bettendorf, 2025). People make more careful choices and take steps to protect themselves from possible bad events when they aren't sure what will happen next or think there is a risk (Jeanne and Rancière, 2011; Kimball, 1990). This approach enhances conventional consumption theories, such as Friedman's (1957) Permanent Income Hypothesis and Modigliani's (1966) Life Cycle Income Hypothesis, by incorporating uncertainty into the decision-making framework (Carroll, 1997). You can use this way of thinking to explain how central banks keep their reserves, not just for people or businesses. Central banks save money to protect themselves from losses in the market. This is because the international financial system is becoming less stable, capital movements are becoming less predictable, and there are risks involved in borrowing money from outside sources. Just like people save money when they don't know how much they'll make, central banks build up reserves to keep the economy stable. International reserves are like the economy's "savings for a rainy day" (Obstfeld et al., 2010; Aizenman and Marion, 2003). From a monetary policy point of view, this desire to prevent things from happening has a direct impact on how central banks build up and manage their reserves.

According to a report by Morgan Stanley in 2013, the Indian rupee, Brazilian real, South African rand, Indonesian rupiah, and Turkish lira were declared the "Fragile Five" or the currencies most under pressure against the US dollar. The common characteristics of these economies are their high dependence on external financing, current account issues, and exchange rate sensitivities, making them more vulnerable to global shocks. The lack of sufficient domestic capital needed for growth, largely provided by foreign capital inflows, is one of the reasons why changes in capital flows in global markets

most affect these countries (Ahmed and Zlate, 2014). For these reasons, if a solution is to be found for the problems in the economic structure, it is necessary to first accurately identify the impact of all factors. It is important to examine the effects of policies, but it is also necessary to understand what happens if the policies do not change or if there is uncertainty. One of the most important tools for countries in managing capital flows is international reserves. In this study, examining the connection between uncertainty and reserves will be important for understanding the impact of uncertainty. Policy uncertainty is a factor that affects the decision-making processes of economic units. Additionally, capital flows are also influenced by the policies being implemented and the expectations regarding the future state of these policies. If there is uncertainty regarding the goals and objectives of the future economic process, this uncertainty will negatively affect both decision-making processes and capital flows. From the investors' perspective, the risk will increase during such periods. The inflow of capital into the country will decrease. Capital will move toward more reliable areas, that is, economies where policies can be predicted in the future. Central banks will also face the situation of making difficult decisions regarding reserves. The increase in uncertainty may lead to an increase in reserves as a precaution, but it may also show a tendency to decrease due to capital leaving the country. First and foremost, the reserves need to be at an adequate level. To illustrate the situation in the literature regarding reserve adequacy, countries have been analyzed under a separate heading below. After evaluating the adequacy status, the expected situations with policies are generally shaped according to the status of the policies. It is an important issue for these countries to understand how reserves will be affected when policies are uncertain or become uncertain due to the introduction of too many goals and objectives. Understanding these effects will contribute to the formulation of more effective policies during external shocks or times of crisis. In addition, the findings obtained from the study will provide significant insights to economic management by revealing the effects of policies aimed at reducing policy uncertainty on reserves.

The main motivation of the study is to analyze how the reserves of the group of countries that are in the weakest position in the face of capital flows and external shocks between 2005-2025 are affected by policy uncertainty.It is thot that the study will contribute to the existing literature from different perspectives. First, the relationship between the Economic Policy Uncertainty Index and reserves is addressed using the panel data analysis method for both the short term and the long term. In many studies in the literature, the impact of macroeconomic variables on central bank reserves has been examined. (Obstfeld et al., 2010; Aizenman and Sun, 2012). However, studies on the macroeconomic impact of uncertainty and its response to reserve stocks or future reserve levels have been limited. Secondly, it aims to provide a new perspective to the literature by revealing the impact of uncertainty on reserve stock levels and how reserves will form in the future. Additionally, this dynamic relationship has not been addressed for a group of countries with high sensitivities, such as the "Fragile Five." With the belief that the Fragile Five countries should be examined in isolation due to their unique characteristics, these countries have been studied in the research. The study was conducted using data covering the period

from 2005 to 2025, a timeframe that includes the Mortgage Crisis and the Covid-19 pandemic period, as well as subsequent periods, allowing for the examination of multiple external influences on the countries. Thirdly, while evaluating whether reserves are within the comfort zone for countries, the study examines how macro factors affect and shape reserves. With these results, it will contribute to the discussions on optimal reserve policy.

The study consists of four sections. In the first section, the reason for choosing the topic and its importance are discussed, and the reserve adequacies of the countries are compared comparatively. In the second section, the results obtained from previous studies in the literature are discussed. Then, in the third section, which includes the data set and analyzes, the findings are discussed. As the final section, the fourth chapter presents the results obtained and policy recommendations.

1.1. Indicators of Adequacy of International Reserves

The question of what level of reserves countries' central banks should maintain has been the subject of research in the literature, particularly after the financial crisis in Asia in the 1990s (BIS, 2011). There are two main approaches that are most widely accepted regarding the level of international reserves: the Guidotti–Greenspan rule and the Assessing Reserve Adequacy (ARA) metric developed by the IMF. Explaining and evaluating these approaches for countries will be useful for the results that this study aims to present. The main purpose of the Guidotti–Greenspan rule is based on the principle that countries should have the ability to meet their short term-1 year- external debts with their international reserves. In this way, it is based on the assumption that if the country's access to external financing is completely cut off, i.e., if no external resources come into the country, the reserves should be at a level that can pay off existing external debts (Greenspan, 1999). The main purpose of this rule is to create a level of security that will prevent short-term exchange rate pressure on economies. In this sense, the Guidotti–Greenspan ratio is primarily designed to capture sudden stop risk, as it reflects a country's capacity to meet short-term external obligations in the event of an abrupt halt in capital inflows. In this context, the ratio obtained by comparing reserves to short-term external liabilities must be at least 1. In short, there must be a minimum of international reserves sufficient to pay short-term external liabilities.

Table 1. Reserve Ratios in Fragile Five Countries According to the Guidotti–Greenspan Rule

Years	Brazil	India	Indonesia	South Africa	Türkiye
2004	1.0	2.5	1.7	0.9	0.6
2005	1.1	2.9	1.5	0.9	0.7
2006	1.6	3.1	2.1	1.0	0.7
2007	2.3	3.7	2.1	1.0	0.8
2008	2.4	2.9	1.7	1.0	0.7
2009	3.2	2.8	2.1	1.2	0.7
2010	3.1	2.5	1.7	1.3	0.6

2011	3.9	2.0	1.7	1.4	0.6
2012	4.0	1.6	1.5	1.1	0.7
2013	3.5	1.6	1.3	1.3	0.7
2014	2.3	1.8	1.4	1.0	0.7
2015	2.4	1.8	1.9	1.1	0.7
2016	2.4	1.9	2.1	1.2	0.7
2017	2.6	2.0	2.4	0.9	0.6
2018	2.4	1.9	2.0	0.9	0.6
2019	2.0	2.1	2.0	1.0	0.7
2020	2.3	2.6	2.1	1.2	0.6
2021	2.4	2.5	2.4	1.4	0.7
2022	2.1	2.2	2.1	1.2	0.7
2023	2.1	2.4	2.1	1.3	0.6
2024	1.8	2.2	1.9	1.3	0.7
2025	1.8	2.2	1.7	1.4	0.7

Source: (IMF, 20.12.2025)

When we examine the Fragile Five countries in accordance with the Guidotti–Greenspan rule for the time period under analysis, it is seen that South Africa did not have sufficient reserve levels in some years, and Türkiye did not have sufficient reserve levels throughout the entire period examined. Brazil, India, and Indonesia were found to have reserve levels sufficient to meet their short-term liabilities in all years. Policymakers have long referenced the Guidotti–Greenspan rule due to its ease of application. However, focusing only on short-term liabilities is insufficient. Sudden capital outflows, deficits that may arise due to the dynamic nature of foreign trade, and exchange rate risks must also be taken into account (BIS, 2011). Taking these issues into consideration, the IMF (2011) developed the more comprehensive Assessing Reserve Adequacy (ARA) metric. The ARA metric is constructed with an approach that considers short-term external debt stock, liabilities arising from portfolio investments, broad money supply (M2), and finally, export revenues. Specific risk weights are defined for each component that makes up the metric. In fixed exchange rate regimes, central banks need more reserves to meet foreign exchange demand, so the weights of this component are increased. In more flexible exchange rate regimes, however, the weight is reduced because lower reserve requirements are anticipated (IMF, 2016; IMF, 2013). In this respect, risk management is carried out with a broader assessment than the "minimum liquidity buffer" approach offered by the Guidotti–Greenspan rule. Today, the IMF and central banks use both approaches together when evaluating reserve adequacy; they also consider factors such as financial openness, exchange rate regime, and the structure of capital movements, in addition to the level of short-term external debt (IMF, 2016; Obstfeld et al., 2010). According to these indicators, insufficient reserve levels increase the financial vulnerability of national economies, while excessive reserves are also undesirable. In the case of excessive reserves, economic efficiency may decrease due to opportunity costs.

Table 2. Reserve Ratios in Fragile Five Countries According to the ARA Metric

Years	Brazil	India	Indonesia	South Africa	Türkiye
2004	0.71	2.16	0.99	0.57	0.78
2005	0.64	2.01	0.95	0.65	0.90
2006	0.81	2.20	1.06	0.67	0.91
2007	1.17	2.56	1.20	0.69	0.87
2008	1.61	2.11	1.18	0.87	0.86
2009	1.33	1.96	1.23	0.84	0.85
2010	1.29	1.75	0.93	0.74	0.83
2011	1.56	1.59	1.39	0.87	0.84
2012	1.59	1.43	0.89	0.79	0.93
2013	1.59	1.43	1.19	0.82	0.98
2014	1.55	1.51	1.21	0.74	0.92
2015	1.92	1.57	1.22	0.86	0.90
2016	1.66	1.56	1.28	0.78	0.90
2017	1.60	1.61	0.88	0.63	0.81
2018	1.66	1.53	1.16	0.72	0.79
2019	1.47	1.71	1.15	0.74	0.89
2020	1.64	1.93	1.25	0.80	0.78
2021	1.67	1.87	1.26	0.86	0.95
2022	1.37	1.77	1.16	0.89	0.72
2023	1.27	1.13	1.21	0.96	0.72
2024	1.26	1.10	1.25	0.98	0.72
2025	1.21	1.11	1.19	1.01	0.75

Source: (IMF, 20.12.2025)

Table 2 shows that South Africa and Türkiye don't have very strong reserve adequacy profiles because their ratios stayed below 1 for most of the time we looked at. If the ARA framework shows a ratio below 1 (100 percent), it means that there aren't enough reserve buffers to protect the organization from shocks from outside. If the ratio is 1 or higher , there is enough reserve coverage. The IMF (2016) says that a ratio of 1 to 1.5 is good. A ratio of less than 1 means you don't have enough reserves, and a ratio of more than 1.5 means you have too many . In this case, you miss out on a big opportunity cost because you can't use extra reserves for other things, like paying off debt or making public investments. This makes it hard to use resources in the best way.

The reserve/ARA ratios of South Africa and Türkiye are both less than 1, which means that these countries don't have much of a buffer against shocks from outside. In the past few years, these economies have become more sensitive to changes in capital, exchange rates, and the costs of rolling over external debt. In conclusion , the ARA metric data for the Fragile Five countries from 2005 to 2025 shows that the countries have very different levels of reserve adequacy. Most of the time, Indonesia, India, and Brazil have reserve/ARA ratios higher than 1. This means that they can handle shocks from outside better than most other countries. But South Africa and Türkiye always have ratios below 1. This means

that their reserves aren't big enough to cover the risks of borrowing money from other countries, which makes it more likely that money will leave the country and the exchange rate will change. During the time period that was looked at, Brazil and India also had ratios that were mostly higher than 1.5. This means that they need to rethink their policies for managing their reserves because they have too many and can not use them for anything else.

2. LITERATURE

International reserves are among the key topics discussed in economic literature. Traditional approaches state that increasing reserves serves purposes such as closing balance of payments deficits, protecting the economy against sudden capital movements, and supporting exchange rate stability (Obstfeld et al., 2010). However, in today's conditions of increasing globalization, diversifying risks, and constantly changing communication channels, explaining reserve accumulation policies solely through these classical justifications is insufficient. Therefore, the reasons for changes in international reserves need to be re-evaluated from different perspectives.

2.1. Studies on the Relationship Between Policy Uncertainty and Reserves

Baker, Bloom, and Davis (2016) made the Economic Policy Uncertainty (EPU) index. It is a leading indicator that shows how the perception of policymakers' policies as being unpredictable by decision-making units in the economy affects how they make decisions. As the index value goes up, investors feel more risk, investments go down, money leaves the country, and the foreign exchange market becomes unstable. In these kinds of situations, central banks try to stop possible economic problems by raising their levels of international reserves (Aizenman and Ito, 2022). Aizenman and Sun's (2012) study, one of the first on this subject, showed that the rise in reserves in Asian economies was not only caused by current account deficits and the foreign exchange market, but also by policy instability. In a study on emerging market economies, Ghosh, Ostry, and Tsangarides (2012) noted that central banks attempt to manage risks by increasing their international reserve levels in situations of increased uncertainty. Bussière, Cheng, Chinn and Lisack (2015) demonstrated that reserves increase in response to rising indicators of financial uncertainty, a distinct category of uncertainty. Therefore, when economies are uncertain , people tend to perceive risks more acutely, which leads them to want to increase the amount of international reserves.

2.2. Studies in the Context of the Fragile Five Countries

Brazil, Türkiye, India, South Africa, and Indonesia are some of the countries that are more vulnerable than others because they don't have enough savings at home and rely heavily on foreign capital markets. Ahmed and Zlate (2014) said that changes in US interest rates and global market uncertainty affect this group of countries, which leads to capital outflows. To lessen this bad effect, their

central banks are trying to build up their reserves. Gilal and Ismail (2025) looked at the BRIC countries, which are Brazil, India, and others. They discovered that when economic indicators improve, reserves go up in the short term but down in the long term. Studies that focus only on Türkiye show that, like in other countries, people want to build up their reserves when the world is less stable (Aizenman and Sun, 2012). Aizenman and Ito (2022) looked at 27 emerging economies after COVID-19 and found that policy uncertainty and the risk situation in financial indicators made people more likely to want to build up national reserves. So, the state of international reserves is very important for economies that are sensitive to capital flows, like those in the Fragile Five. Jeanne and Rancière (2011) said that building up reserves is good for preventing crises, but it can also make investments and productivity more expensive in the long run. Increasing reserves can help boost economic confidence and stability at first, but after a certain point, the cost becomes a problem for countries that don't have enough capital.

In this context, the relationship between policy uncertainty and reserves is not one-way, but a dynamic process that varies depending on the period and country characteristics. While existing studies mostly focus on Asian or Latin American countries, studies that comparatively examine the relationship between economic policy uncertainty and reserve accumulation specifically in the Fragile Five countries are quite limited.

Table 3. Studies Investigating the Relationship Between EPU and Reserves

Author(s)	Period / Country	Methodology	Key Results
Obstfeld, Shambaugh and Taylor (2010)	1970–2008, 50 countries	Panel	Reserve accumulation is associated with financial openness and the exchange rate regime.
Aizenman and Lee (2007)	1975–2004, Asian countries	GMM	Reserves are increased for precautionary purposes.
Aizenman and Sun (2012)	2008–2009, 21 EMEs	Panel	When global uncertainty increases, the reserve demand of rises
Bussière et al. (2015)	1999–2013, 45 countries	Panel VAR	During periods of financial uncertainty, reserve accumulation increases.
Baker, Bloom and Davis (2016)	1985–2014, USA	Index development	EPU influences economic decisions and capital flows.
Demir and Ersan (2017)	2003–2016, Türkiye	ARDL	The increase in US EPU and VIX increases the CBRT reserves.
Gilal and Ismail (2025)	2003-2023, BRIC	ARDL	EPU has a positive effect in the short term and a negative effect in the long term.
Aizenman and Ito (2022)	2000–2021, 27 emerging countries	Panel ARDL	Uncertainty increases the motivation to accumulate reserves.
Ghosh, Ostry and Tsangarides (2017)	1980–2015, developing countries	GMM	Reserves are higher in countries with higher financial fragility.
Ahmed and Zlate (2014)	2003–2013, Fragile 5	Panel	US interest rate hikes and uncertainty affect reserve movements.
Jeanne and Rancière (2011)	1970–2008, 45 countries	Theoretical model	Accumulating reserves is beneficial but costly in the long run.

In conclusion, the literature indicates that ambiguity regarding economic policy significantly influences capital flows, exchange rates, and reserve movements. But recent studies show that their methods, data structure , and empirical results are very different from each other. Ghosh et al. (2017) and Aizenman and Lee (2007) are two early studies that use GMM-based panel methods to look at precautionary reasons. Subsequent research examines short- and long-term dynamics through ARDL, panel VAR , or panel ARDL methodologies. Some studies focus on the economies of Asia or BRIC, while others examine extensive groups of nations. Not all empirical findings are identical . Some research says that uncertainty helps people build up their reserves, while other research says that the connection between uncertainty and reserves isn't the same for everyone or changes over time. However, the absence of a panel approach incorporating structural breaks to test this relationship in the Fragile Five countries indicates that your study will provide a distinctive contribution that addresses a gap in the literature, both theoretically and practically.

3. DATA SET

This study examines the period 2005:3–2025:1 for the economies of Türkiye, Brazil, India, Indonesia, and South Africa, known as the Fragile Five, using quarterly data. The rationale for examining this group of countries is that they have current account deficit problems due to import surpluses in their foreign trade, they need foreign capital for their growth and development goals, and there is a relationship between limited foreign exchange reserves and financial stability (Ahmed and Zlate, 2014). The variables used in the study consist of central bank gross foreign exchange reserves, key macroeconomic indicators that can affect reserve dynamics, and the economic policy uncertainty index. The logarithmic forms of the reserves, gross domestic product, and dollar exchange rate variables in the dataset were used in the analyses. The Economic Policy Uncertainty (EPU) index is used in its original country-level index form without logarithmic or ratio transformation, in order to preserve its standardized scale and cross-country comparability.

Table 4. Explanations and Sources of Data

Variable	Explanation	Transformation	Frequency	Source
Gross foreign exchange reserves (LRES)	Gross reserves, billion USD	Logaritmic	Quarterly	International Monetary Fund (IMF)
Inflation Rate(I)	CPI change, %	Level (percentage)	Quarterly	Federal Reserve Bank (FRED)
Gross Domestic Product (LGDP)	GDP, current prices, expenditure approach	Logaritmic	Quarterly	World Bank (WDI)
Policy interest rate (PR)	Policy rate, %	Level (percentage)	Quarterly	International Monetary Fund (IMF)
Nominal exchange rate (EXC)	Local currency per USD, 3-month average	Logaritmic	Quarterly	International Monetary Fund (IMF)

Economic Policy Uncertainty Index (EPU)	Country-based uncertainty index	Level (index form, no transformation)	Quarterly	PolicyUncertainty.com

The reason the time interval cannot go further back is due to the unavailability of country data. The oldest available period for countries, especially for the policy uncertainty index, is 2005. This constraint determined the starting time period. The period following the global mortgage crisis at the end of 2008 and the beginning of 2009 was a period in which developing country central banks reviewed and redefined their reserve accumulation policies. This period also saw increased uncertainty (Aizenman and Ito, 2022). To avoid comparison problems due to the different magnitudes of the data, gross domestic product, gross foreign exchange reserves, and the dollar exchange rate were subjected to logarithmic transformation. Stationarity tests were conducted, and the presence of linearity in the variables was additionally examined before panel analyses. Ramsey (1969) stated that linearity violation leads to specification errors, resulting in unreliable estimates and test results.

3.1. Empirical Findings

Descriptive statistics for the variables are shown in Table 2. According to the Jerqua-Bera test results for all series in the dataset of 395 observations, the assumption of normal distribution is strongly rejected at the 1% significance level.

Table 5. Descriptive Statistics

Series	Observation	Mean	Standard Deviation	Minimum	Maximum	Jarque-Bera	Probability
LRES	395	2.10	0.38	1.23	2.85	23.43	0.000
I	395	1.86	2.37	-0.42	28.29	16223.34	0.000
LGDP	395	6.99	1.38	5.21	9.76	55.40	0.000
PR	395	8.82	6.04	2.00	50.00	9258.11	0.000
EXC	395	3.64	2.64	0.16	9.77	62.11	0.000
EPU	395	0.31	0.30	0.00	1.92	630.59	0.000

In Brazil, where the inflation variable reached its lowest value, it was -0.42 in the first quarter of 2024. The highest value in the data showing the change compared to the previous period was observed in Türkiye in 2022. It is seen that the gross domestic product variable has the highest average and the policy uncertainty index value has the lowest average. The fact that the policy interest rate has the highest standard deviation indicates that it is the variable that has been subjected to the most adjustments during this period and that it is the tool that has been adjusted more frequently by the countries examined in terms of monetary policy compared to other variables. Looking at the table, the difference between the average and the maximum value is again largest in the policy interest rate variable. This shows that monetary policy uses stable interest rates in normal periods, but resorts to sudden and sharp jumps in crisis periods.

The main objective of this study is to examine the effect of economic policy uncertainty on central bank reserves. The basic model created in this direction is expressed as follows:

$$RES_{it} = \alpha_i + \beta_1 EPU_{it} + \beta_2 GDP_{it} + \beta_3 I_{it} + \beta_4 EXC_{it} + \beta_5 PR_{it} + \varepsilon_{it} \tag{1}$$

Here: α_i represents the country-specific fixed effects; RES_{it} represents the countries' international reserves during the period; EPU_{it} represents the economic policy uncertainty index; GDP_{it} represents the gross domestic product; I_{it} represents the inflation rate; EXC_{it} represents the exchange rate; PR_{it} represents the policy interest rate; ε_{it} represents the error term. According to expected theoretical signals, an increase in EPU (Economic Purchase Programme) is expected to positively affect reserves, interest rate and growth increases are expected to increase reserves through capital inflows, while inflation and exchange rate increases are expected to decrease reserves (Aizenman and Sun, 2012). Panel data models generally rely on the assumption that there is a linear relationship between the dependent variable and the independent variables. Therefore, correctly defining the form of the relationship between the variables before constructing the model is important for the reliability of the results obtained (Baltagi, 2021). The linearity test performed before panel data analysis is applied to evaluate whether the functional form of the model is appropriate. The linearity assumption predicts that the dependent variable is related to the explanatory variables through a constant slope parameter. However, threshold-dependent, asymmetric, or nonlinear relationships may exist between economic variables. In such cases, classical panel models (Fixed Effects or Random Effects models) may not fully reflect the relationships (Hansen, 1999). In this context, while performing a linearity test is not a mandatory step in panel data analysis, it can be particularly useful in identifying the presence of asymmetric effects in financial and macroeconomic relationships and in reducing model specification errors, thereby increasing the reliability of parameter estimates.

Table 6. Harvey et al. Linearity Test Results

Variables	W-Lam	Critical Values			Conclusion
		10%	**5%**	**1%**	
LRES	4.58	41.79	42.18	42.89	Linear
I	5.01	17.27	17.31	17.37	Linear
LGDP	27.43	50.37	50.67	51.21	Linear
PR	2.51	4.59	4.60	4.62	Linear
EXC	15.44	18.45	18.50	18.58	Linear
EPU	8.31	10.09	10.13	10.20	Linear

According to the linearity test results in Table 6, the variables exhibit linear characteristics.

Table 7. Correlation Matrix

Variables	LRES	PR	EPU	LGDP	I	EXC
LRES	1.00					
PR	-0.14	1.00				
EPU	-0.02	-0.24	1.00			
LGDP	0.18	-0.23	0.67	1.00		
I	-0.25	0.02	-0.28	-0.34	1.00	
EXC	-0.10	0.57	-0.07	-0.06	0.05	1.00

The results of the correlation matrix, which was created to ensure there is no multicollinearity problem in the model, are shown in Table 7. The generally negative correlations between reserves and

other variables indicate that international reserves have an inverse relationship with the policy interest rate, economic policy uncertainty, economic size, inflation, and exchange rate. The positive and high correlation between the policy interest rate and inflation variables reflects the sensitivity of interest rates to inflation dynamics and the effectiveness of the monetary policy transmission mechanism. The high positive correlation between economic growth and the exchange rate indicates a strong bidirectional relationship between them. The negative relationship between policy uncertainty and exchange rate variables suggests that increased policy uncertainty may weaken exchange rate stability. In general, the absolute values of the correlation coefficients remaining below 0.8 indicate the absence of a multicollinearity problem.

The methods used to test for the presence of cross-sectional dependence in panel data analyses differ according to the size of the panel (N and T). The LM test, developed by Breusch and Pagan (1980), is used to examine whether there is a correlation between units in panels with a large time dimension (T > N). Results may be biased when the time dimension is small. However, Pesaran (2004) proposed the CDLM and CD tests as tests that can be valid in both T > N and T < N cases. The CDLM test is an extended version of the LM test and is effective in medium-sized panels. The CD test is used in panels with large N and T values. Furthermore, the LMadj test, developed by Pesaran and Yamagata (2008), is a more robust version of the classical LM test. In this study, the CDLM test was applied because T=21 and N=5.

Table 8. Cross-Section Dependency

	Variables	LM	CD$_{LM}$	CD	LM$_{adj}$
LRES	Test Statistics	20.167***	2.272**	-3.037***	1.550***
	Probability (P value)	0.008	0.012	0.001	0.001
LGDP	Test Statistics	21.389**	2.547***	-2.742***	18.628***
	Probability (P value)	0.019	0.005	0.003	0.000
EXC	Test Statistics	32.725***	5.082***	-2.090**	4.396***
	Probability (P value)	0.000	0.000	0.018	0.000
PR	Test Statistics	16.171***	1.380***	-2.996***	1.965**
	Probability (P value)	0.005	0.004	0.001	0.025
I	Test Statistics	39.299***	6.551***	-3.055***	0.462***
	Probability (P value)	0.000	0.000	0.001	0.003
EPU	Test Statistics	25.720***	3.515***	-3.037***	3.066***
	Probability (P value)	0.004	0.000	0.001	0.001

Note: *** sign indicates 1% significance level, ** sign indicates 5% significance level, and * sign indicates 10% significance level.

The findings indicate that all variables exhibit significant cross-sectional dependence at the 1% level. This suggests that economic variables among the fragile five countries are highly interdependent and that the error terms in the panel are not independent. Therefore, the next step in panel data analysis should involve the use of second-generation tests that consider inter-unit dependence.

Table 9. CADF Unit Root Test Results

Countries/ Variables	LRES		LGDP		EXC		PR		I		EPU	
	S	S+T	S	S+T	S	S+T	S	S+T	S	S+T	S	S+T
Türkiye	-6.14	-6.09	-4.89	-4.76	-5.90	-5.91	-6.19	-6.35	-4.56	-4.54	-4.96	-4.92
Brazil	-6.99	-6.98	-8.47	-8.48	-5.10	-5.12	-6.22	-6.17	-5.07	-5.03	-6.57	-6.52
India	-6.11	-6.11	-10.0	-10.0	-5.29	-5.23	-5.10	-5.46	-5.34	-5.31	-7.39	-7.35
Indonesia	-7.76	-7.70	-8.00	-7.95	-5.94	-5.89	-5.10	-5.06	-5.28	-5.25	-6.32	-6.28
S. Africa	-6.21	-6.17	-5.60	-5.91	-5.35	-5.28	-5.08	-5.08	-4.91	-4.91	-5.71	-5.65

Note: For the constant model (S), the critical values at the 1%, 5%, and 10% significance levels are -2.53, -2.32, and -2.21, respectively. For the constant+trend (S+T) model, the critical values at the 1%, 5%, and 10% significance levels are -3.03, -2.83, and -2.72, respectively.

For each country comprising the panel, the CADF unit root test developed by Pesaran (2007) was applied, and the results are presented in Table 6. The CADF (Cross-Sectionally Augmented Dickey-Fuller) test results show that all test statistics are greater than the absolute value of the critical value when compared with the critical values at the 1% significance level for the constant model and the constant+trend model. These findings indicate that all variables are stationary at the level (I(0)) and that the series does not contain a unit root.

Table 10. CIPS Test Results

Variables	Fixed Model				Fixed and Tendency Model			
	Test stat.	Critical Values			Test stat.	Critical Values		
	CHIPS	0.01	0.05	0.10	CHIPS	0.01	0.05	0.10
LRES	-1.43	-2.53	-2.32	-2.21	-2.24	-3.03	-2.83	-2.72
LGDP	-2.15	-2.53	-2.32	-2.21	-2.96	-3.03	-2.83	-2.72
EXC	-0.35	-2.53	-2.32	-2.21	-1.27	-3.03	-2.83	-2.72
PR	-1.54	-2.53	-2.32	-2.21	-2.19	-3.03	-2.83	-2.72
I	-5.97	-2.53	-2.32	-2.21	-6.18	-3.03	-2.83	-2.72
EPU	-5.56	-2.53	-2.32	-2.21	-5.61	-3.03	-2.83	-2.72
ΔLRES	-6.19	-2.53	-2.32	-2.21	-6.64	-3.03	-2.83	-2.72
ΔLGDP	-5.83	-2.53	-2.32	-2.21	-6.15	-3.03	-2.83	-2.72
ΔEXC	-5.79	-2.53	-2.32	-2.21	-6.23	-3.03	-2.83	-2.72
ΔPR	-4.24	-2.53	-2.32	-2.21	-4.30	-3.03	-2.83	-2.72

According to the CIPS test, some variables are not stationary at the level values; however, all series become stationary when their first differences are taken. After determining the stationarity levels of the series using CIPS and CADF tests, the CCEMG estimator (Chudik and Pesaran, 2015), which can take into account cross-sectional dependence and heterogeneity, was used, and the results are presented in Table 11.

Table 11. CCEMG Coefficient Estimation Results

Variable	Coefficient	Std. Error	Probability (P value)
ΔEXC	-0.02076	0.01505	0.168
ΔPR	-0.00666	0.00362	0.066*
ΔLGDP	0.00003	0.00153	0.259
I	-0.01020	0.00333	0.002***
EPU	0.01552	0.02083	0.456
ΔLRES_csa	1.02736	0.22604	0.000***
ΔEXC_csa	0.00125	0.00120	0.298
ΔPR_csa	0.00768	0.00802	0.338
ΔLGDP_csa	-0.00001	0.00005	0.909
I_csa	0.01519	0.01554	0.328
EPU_csa	-0.02027	0.06234	0.745
Wald χ2	207.72		0.000***

Note: *** sign indicates 1% significance level, ** sign indicates 5% significance level, and * sign indicates 10% significance level.

Analysis using the CCEMG estimator shows that the model is statistically significant, as evidenced by the Wald statistic probability value. Considering short-term effects and sensitivity to common shocks, the analysis indicates that increases in interest rates reduce reserves. Increases in inflation also reduce reserves. Deterioration of price stability leads to the depletion of reserves.

Table 12. Panel Augmented Mean Group Estimation Results

Variable	Coefficient	Std. Error	Probability (P value)
ΔPR	0.0016	0.0150	0.915
EPU	0.2125	0.0614	0.001***
ΔLGDP	0.00115	0.0076	0.132
I	-0.0026	0.0156	0.867
ΔEXC	0.0375	0.0394	0.340
Constant	2.0450	0.1765	0.000***
Wald χ2	14932.83		0.000***
RMSE	0.1447		

Note: *** sign indicates 1%. RMSE (Root Mean Square Error) represents the root mean square of the mean regression error squares, and Wald Statistics represents the general significance of the established models.

The Augmented Mean Group (AMG) estimator is an analysis that considers the long-term effects of variables. According to the results, only the economic policy uncertainty index is statistically significant in its effect on international reserves. A positive index coefficient indicates that reserves increase with increasing economic policy uncertainty. The effects of other independent variables on reserves were not found to be significant. Except for the index variable, the effects of other variables on reserves during the period examined may have been very weak, or may have varied depending on the country, resulting in no effect at all. In summary, policy uncertainty is prominent in explaining the behavior of reserves, while other macroeconomic variables are less decisive. To increase the consistency of the model and the reliability of the results in panel data analysis, different estimators were used together. First, the Augmented Mean Group method provides the average of the unit-specific coefficients by considering the heterogeneity and common dynamic processes in the panel. Then, the CCEMG estimator strengthens the generalizability of the model by considering possible cross-sectional dependence and common factor struckeye. Finally, the Driscoll and Kraay (1998) estimator was used to test the robustness of the obtained results against autocorrelation, heteroskedasticity, and cross-sectional

dependence. Thus, the stability of the model was evaluated by comparing the consistency of the results obtained with different estimators.

Table 13. Driscoll-Kraay Fixed Effects Regression Results with Standard Errors

Variable	Coefficient	Driscoll-Kray Std. Error	Probability (P value)
ΔPR	-2.8153	1.600599	0.083*
EPU	48.4121	14.52065	0.001***
ΔLGDP	0.00308	1.935401	0.000***
I	1.90330	0.000403	0.328
ΔEXC	-0.0068	0.002573	0.000***
_cons	187.3367	12.23233	0.000***
Probe>F			0.000***
F	38.29		

Note: *** sign indicates 1% significance level, ** sign indicates 5% significance level, and * sign indicates 10% significance level.

According to the regression results, reserves have a positive and significant effect on economic policy uncertainty and economic growth. However, they have a negative and significant effect on the exchange rate. While the policy interest rate shows a negative relationship, it is only significant at the 10% level. The inflation variable was not found to be statistically significant. Overall, the model explains a portion of the change in reserves. To determine the causal relationship between the variables and to account for heterogeneity in the panel, the Dumitrescu and Hurlin (2012) panel causality test was applied. This test allows for reliable results despite possible cross-sectional dependence between panel units. The test results are presented in Table 14.

Table 14. Dumitrescu-Hurlin Causality Results

Dependent → Independent	W-bar	Z-bar	Z-bar tilde	P-value	Causality Comment
RES → PR	1.0153	0.0242	-0.0182	0.9810	Ineffective
RES → EPU	3.072	3.2762	3.0822	0.0011**	Effective
RES → GDP	2.0288	1.6267	1.5096	0.1040	Ineffective
RES → I	3.4243	3.8331	3.6132	0.0003**	Effective
RES → EXC	2.8194	2.8766	2.7013	0.0040***	Effective
PR → RES	0.6312	-0.5831	-0.5972	0.5598	Ineffective
PR → EPU	0.1446	-1.3525	-1.3307	0.1833	Ineffective
PR → GDP	1.5239	0.8283	0.7484	0.4542	Ineffective
PR → I	4.9584	6.2587	5.9257	0.0000***	Effective
PR → EXC	2.242	1.9638	1.831	0.0596*	Effective
EPU → RES	0.9055	-0.1493	-0.1837	0.8813	Ineffective
EPU → PR	0.939	-0.0965	-0.1333	0.8940	Ineffective
EPU → GDP	1.4156	0.6571	0.5852	0.5584	Ineffective
EPU → I	0.672	-0.5187	-0.5358	0.5921	Ineffective
EPU → EXC	0.3931	-0.9595	-0.9561	0.3390	Ineffective
GDP → I	4.5426	5.6013	5.299	0.0000***	Effective
GDP → EXC	7.6516	10.517	9.9857	0.0000***	Effective
I → RES	1.0753	0.119	0.0722	0.9424	Ineffective
I → PR	11.825	17.117	16.2776	0.0000**	Effective
I → EPU	0.1833	-1.2914	-1.2725	0.2032	Ineffective

I → EXC	6.9785	9.4529	8.9711	0.0000***	Effective
EXC → RES	2.1348	1.7943	1.6694	0.0950*	Effective
EXC → PR	3.2789	3.6032	3.394	0.0003***	Effective
EXC → EPU	0.3931	-0.9595	-0.9561	0.3390	Ineffective
EXC → I	5.0108	6.3416	6.0048	0.0000***	Effective

Note: *** sign indicates 1% significance level, ** sign indicates 5% significance level, and * sign indicates 10% significance level.

According to the panel causality test results, unidirectional causal relationships are observed between reserves and some macroeconomic variables. In particular, a significant causality is observed from reserves to the policy uncertainty index, inflation, and exchange rate. Similarly, policy interest rate and inflation variables affect some macroeconomic indicators. Economic policy uncertainty, however, was found to have no effect on most variables. In general, inflation and exchange rate variables have a strong causal effect on other variables. In this context, while long-run cointegration findings reveal the existence of a permanent equilibrium relationship between variables, causality analyses provide information about the direction of this relationship. Therefore, causality results are considered to support the interpretation of long-run coefficients, but are not taken as evidence of direct long-run effects.

Overall, the empirical findings are largely consistent across different estimation methods. In the long-run results, the coefficient of the economic policy uncertainty variable is positive and statistically significant. This suggests that as uncertainty increases, central banks increase their reserves for precautionary purposes. On the other hand, the effects of other macroeconomic variables are mostly weak or statistically insignificant. The similar results in terms of sign and significance among the CCEMG, AMG and Driscoll Kraay estimators support the robustness of the findings and the reliability of the main conclusion of the study.

4. CONCLUSION

According to the Guidotti–Greenspan rule and the Assessing Reserve Adequacy (ARA) metric developed by the IMF, international reserves appear insufficient, particularly for South Africa and Türkiye. Increasing reserves is crucial for these countries. The analyses applied in this study show that inflation has a strong impact on reserves in the short term, and that reserves are shaped by common global shocks. Considering that reserve accumulation weakens or the impact of reserves decreases in the Fragile Five group of countries during periods of price instability, stabilization policies will also positively affect reserve levels. The strong and highly significant result of the interaction between common factors and the reserve variable confirms that international reserve policies are largely sensitive to global financial conditions. Economic policy uncertainty (EPU), the main variable whose impact is examined, affects reserves in the long term when evaluated for the panel AMG estimation. This indicates that central banks' motivation to accumulate reserves for precautionary purposes increases during periods of uncertainty. The statistically insignificant nature of inflation, policy interest rate, growth, and exchange rate variables in the long run indicates that the effects of these variables operate primarily

through short-term and indirect channels. The results of the Dumitrescu–Hurlin panel causality test reveal the causal relationships between the variables, as well as explaining the monetary functioning of the Fragile Five countries group examined. Furthermore, it reveals the operation of the monetary transmission mechanism. For the group of countries examined, there is a strong bidirectional causality between the policy interest rate and inflation. The causality from inflation to the policy interest rate emphasizes the importance of price stability for central banks. The causality from the policy interest rate to inflation reveals that the interest rate channel of the monetary transmission mechanism is effective. In the Fragile Five country group, the policy interest rate was the variable with the highest standard deviation value for the period examined. Due to the effectiveness of the interest rate channel, it was found to be the most frequently used monetary policy tool. In addition, there is a unidirectional causality from the exchange rate to the policy interest rate and reserves; A reciprocal, bidirectional causality with inflation has also been identified. For the Fragile Five examined, the importance of all factors that can affect the foreign exchange market, both domestically and internationally, is highlighted.

It is also important for the Central Bank to keep the foreign exchange market stable because the foreign exchange channel has many effects on the economy as a whole. The results also show that reserves cause changes in the exchange rate, policy uncertainty, and inflation in one direction. Reserves are known to be a way to keep the economy and the foreign exchange market stable. It has been shown that reserves do help the markets feel more confident in the Fragile Five. The results show that, in general, reserve policies are affected by short-term changes in global financial conditions and inflation. The results indicate that reserves are influenced by economic policy uncertainty over the long term. However, the causality findings are based on the Granger framework and reflect predictive relationships rather than a direct structural cause–effect mechanism; therefore, the policy implications should be interpreted cautiously and as indicative tendencies rather than definitive conclusions. In this context, it is concluded that monetary policies that are predictable and build confidence while putting price stability first make reserves more adequate and the economy more resilient.

The Fragile Five countries are developing countries, so they need to make sure that their policies are comprehensive and that they protect themselves from possible risks in order to keep growing and developing economically. This will make internal macroeconomic indicators better and make them more resistant to shocks from outside. For resources to be used efficiently, reserves must be kept at a level that is both reasonable and inspires confidence. So, keeping the right amount of reserves will make the economy of the country more stable. People who have to make decisions will be more hopeful about the future if they can trust the markets and get rid of doubt. When people go from being unsure to being hopeful, they will make better decisions. In the end, a level of international reserves that makes people feel safe will help keep macroeconomic stability for a long time.

The limited time frame of the economic policy uncertainty index data constrains the evaluation's scope. Future research should encompass additional uncertainties impacting reserves, alongside

economic uncertainties and country-specific risk scenarios. Another suggestion for future studies is to increase the number of developing countries. This will make it easier to compare them and apply the results to other countries with similar traits. This will facilitate a more profound analysis of the comprehension regarding the assessment of international reserves.

REFERENCES

Ahmed, S. and Zlate, A. (2014) "Capital Flows to Emerging Market Economies: A Brave New World?", Journal of International Money and Finance, 48: 221–248. https://doi.org/10.1016/j.jimonfin.2014.08.002

Aizenman, J. and Ito, H. (2022) "Central Bank Reserves and Financial Vulnerabilities: Emerging Markets After COVID-19", NBER Working Paper, No. 30211. https://www.nber.org/papers/w30211

Aizenman, J. and Sun, Y. (2012) "The Financial Crisis and Sizable International Reserves Depletion: From Fear of Floating to the Fear of Losing International Reserves?", International Review of Economics and Finance, 24: 250–269. https://doi.org/10.1016/j.iref.2012.03.004

Aizenman, J. and Lee, J. (2007) "International Reserves: Precautionary Versus Mercantilist Views, Theory and Evidence", Open Economies Review, 18(2): 191–214. https://doi.org/10.1007/s11079-007-9030-z

Aizenman, J. and Marion, N. (2003) "The High Demand for International Reserves in the Far East: What's Going On?", Journal of the Japanese and International Economies, 17(3): 370–400. https://doi.org/10.1016/S0889-1583(03)00008-X

Baker, S. R., Bloom, N., and Davis, S. J. (2016) "Measuring Economic Policy Uncertainty", Quarterly Journal of Economics, 131(4): 1593–1636. https://doi.org/10.1093/qje/qjw024

Baltagi, B. H. (2021) Econometric Analysis of Panel Data, 6. Baskı, Springer. https://link.springer.com/book/10.1007/978-3-030-53953-5

Bank for International Settlements (2011) "Central Bank Reserves and Sovereign Risk", BIS Papers, No. 58. https://www.bis.org/publ/bppdf/bispap58.htm

Becker, R., Enders, W., and Lee, J. (2006) "A Stationarity Test in the Presence of an Unknown Number of Smooth Breaks", Journal of Time Series Analysis, 27(3): 381–409. https://doi.org/10.1111/j.1467-9892.2006.00478.x

Beckmann, J. and Bettendorf, T. (2025) "Effects of Global Uncertainty on International Portfolio Flows", Deutsche Bundesbank Monthly Report, October. https://www.bundesbank.de/resource/blob/xxxxx/monthly-report-october-2025-data.pdf

Breusch, T. S. and Pagan, A. R. (1980) "The Lagrange Multiplier Test and Its Applications to Model Specification in Econometrics", Review of Economic Studies, 47(1): 239–253. https://doi.org/10.2307/2297111

Bussière, M., Cheng, G., Chinn, M. D., and Lisack, N. (2015) "For a Few Dollars More: Reserves and Growth in Times of Crises", Journal of International Money and Finance, 52: 127–145. https://doi.org/10.1016/j.jimonfin.2014.11.008

Chudik, A. and Pesaran, M. H. (2015) "Common Correlated Effects Estimation of Heterogeneous Dynamic Panel Data Models with Weakly Exogenous Regressors", Journal of Econometrics, 188(2): 393–420. https://doi.org/10.1016/j.jeconom.2015.03.007

Demir, F. and Ersan, O. (2017) "Economic Policy Uncertainty and Cash Holdings: Evidence from BRIC Countries", Emerging Markets Review, 33: 189–200. https://doi.org/10.1016/j.ememar.2017.08.001

Driscoll, J. C. and Kraay, A. C. (1998) "Consistent Covariance Matrix Estimation with Spatially Dependent Panel Data", Review of Economics and Statistics, 80(4): 549–560. https://doi.org/10.1162/003465398557825

Dumitrescu, E. I. and Hurlin, C. (2012) "Testing for Granger Non-Causality in Heterogeneous Panels", Economic Modelling, 29(4): 1450–1460. https://doi.org/10.1016/j.econmod.2012.02.014

Enders, W. and Lee, J. (2012) "The Flexible Fourier Form and Dickey–Fuller Type Unit Root Tests", Economics Letters, 117(1): 196–199. https://doi.org/10.1016/j.econlet.2012.04.081

Ghosh, A. R., Ostry, J. D., and Tsangarides, C. G. (2012) "Shifting Motives: Explaining the Buildup in Official Reserves in Emerging Markets Since the 1980s", IMF Economic Review, 60(2): 303–344. https://doi.org/10.5089/9781463933197.001

Gilal, A. A. and Ismail, N. A. (2025) "Economic Policy Uncertainty and Foreign Reserves: Empirical Evidence from BRIC Countries", International Journal of Economics & Business Administration, 13(2): 3–23. https://ijeba.com/journal/882

González, A., Teräsvirta, T., and Van Dijk, D. (2005) "Panel Smooth Transition Regression Models", Econometric Reviews, 24(3): 307–343. https://doi.org/10.1080/07474930500243019

Greenspan, A. (1999) "Currency Reserves and Debt", World Bank Conference, Washington D.C. https://www.federalreserve.gov/boarddocs/speeches/1999/19990429.htm

Hansen, B. E. (1999) "Threshold Effects in Non-Dynamic Panels: Estimation, Testing, and Inference", Journal of Econometrics, 93(2): 345–368. https://doi.org/10.1016/S0304-4076(99)00025-1

International Monetary Fund (2025) "Assessing Reserve Adequacy (ARA)", IMF Data Mapper. https://www.imf.org/external/datamapper/Reserves_ARA@ARA , (20.12.2025)

International Monetary Fund (2016) "Guidance Note on the Assessment of Reserve Adequacy and Related Considerations", IMF Policy Paper. https://www.imf.org/en/Publications/Policy-Papers

International Monetary Fund (2013) "Assessing Reserve Adequacy – Further Considerations", IMF Policy Paper. https://www.imf.org/en/Publications/Policy-Papers

International Monetary Fund (2011) "Assessing Reserve Adequacy", IMF Policy Paper. https://www.imf.org/en/Publications/Policy-Papers

Jeanne, O. and Rancière, R. (2011) "The Optimal Level of International Reserves for Emerging Market Countries: A New Formula and Some Applications", Economic Journal, 121(555): 905–930. https://doi.org/10.1111/j.1468-0297.2011.02435.x

Kimball, M. S. (1990) "Precautionary Saving in the Small and in the Large", Econometrica, 58(1): 53–73. https://doi.org/10.2307/2938330

Mishra, R. and Datta, A. (2020) "Policy Uncertainty and Foreign Exchange Reserves: Evidence from India", Applied Economics Letters, 27(18): 1482–1487. https://doi.org/10.1080/13504851.2019.1696443

Obstfeld, M., Shambaugh, J. C., and Taylor, A. M. (2010) "Financial Stability, the Trilemma, and International Reserves", American Economic Journal: Macroeconomics, 2(2): 57–94. https://doi.org/10.1257/mac.2.2.57

Pesaran, M. H. and Yamagata, T. (2008) "Testing Slope Homogeneity in Large Panels", Journal of Econometrics, 142(1): 50–93. https://doi.org/10.1016/j.jeconom.2007.05.010

Pesaran, M. H. (2007) "A Simple Panel Unit Root Test in the Presence of Cross-Section Dependence", Journal of Applied Econometrics, 22(2): 265–312. https://doi.org/10.1002/jae.951

Pesaran, M. H. (2004) "General Diagnostic Tests for Cross Section Dependence in Panels", CESifo Working Paper, No. 1229. https://www.cesifo.org/en/publikationen/2004/working-paper/general-diagnostic-tests-cross-section-dependence

Pesaran, M. H., Shin, Y., and Smith, R. J. (1999) "Pooled Mean Group Estimation of Dynamic Heterogeneous Panels", Journal of the American Statistical Association, 94: 621–634. https://doi.org/10.1080/01621459.1999.10474156

Ramsey, J. B. (1969) "Tests for Specification Errors in Classical Linear Least Squares Regression Analysis", Journal of the Royal Statistical Society: Series B, 31(2): 350–371. https://doi.org/10.1111/j.2517-6161.1969.tb00796.x

Rodrigues, P. M. M. and Taylor, A. M. R. (2012) "The Flexible Fourier Form and Local GLS De-Trending Unit Root Tests", Oxford Bulletin of Economics and Statistics, 74(5): 736–759. https://doi.org/10.1111/j.1468-0084.2012.00710.x

Syed, Q. R. (2023) "Climate Policy Uncertainty and Its Impact on Energy Demand: An Empirical Evidence Using the Fourier Augmented ARDL Model", Energy Policy, 168: 113–121. https://doi.org/10.1016/j.enpol.2022.113121